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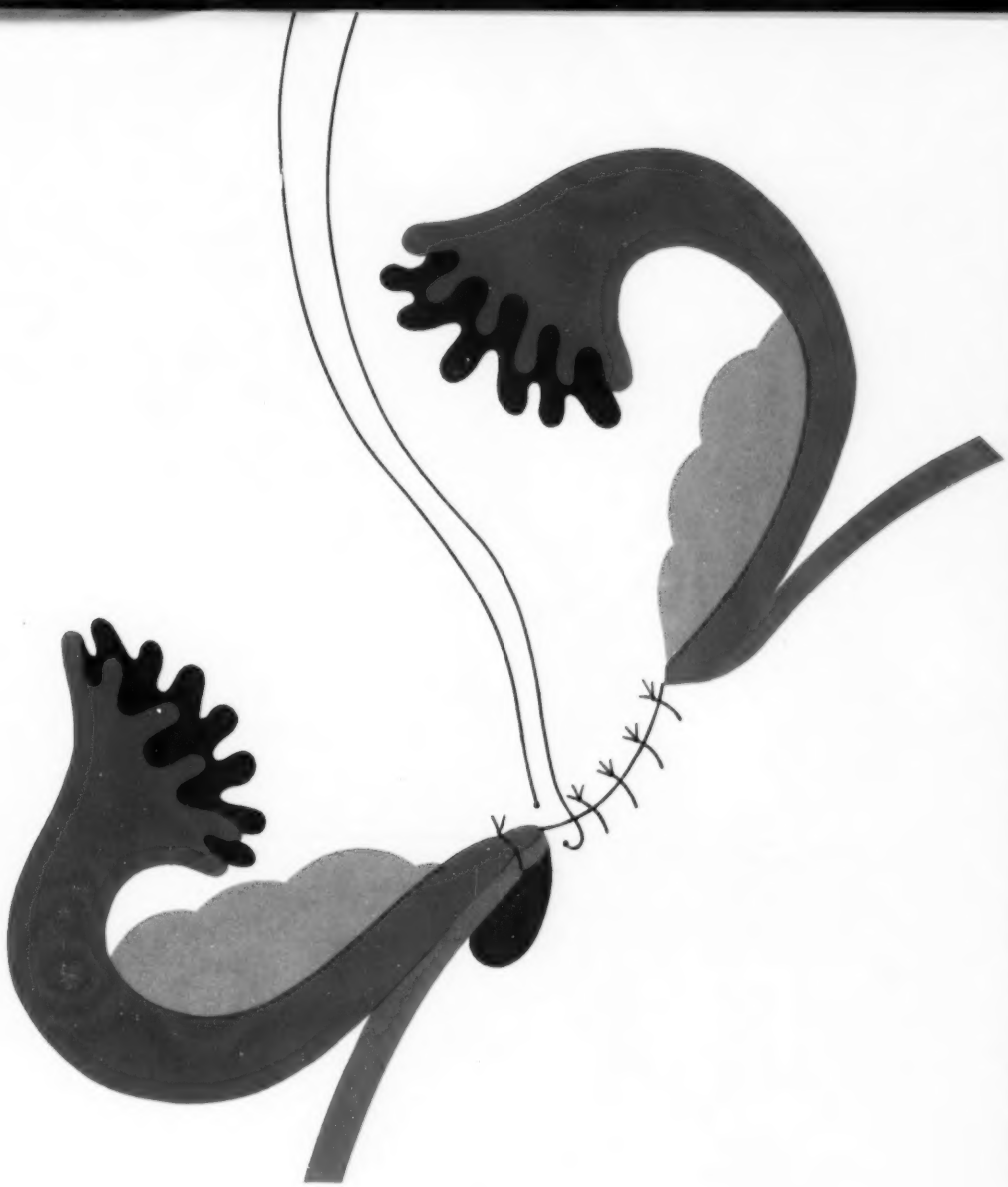

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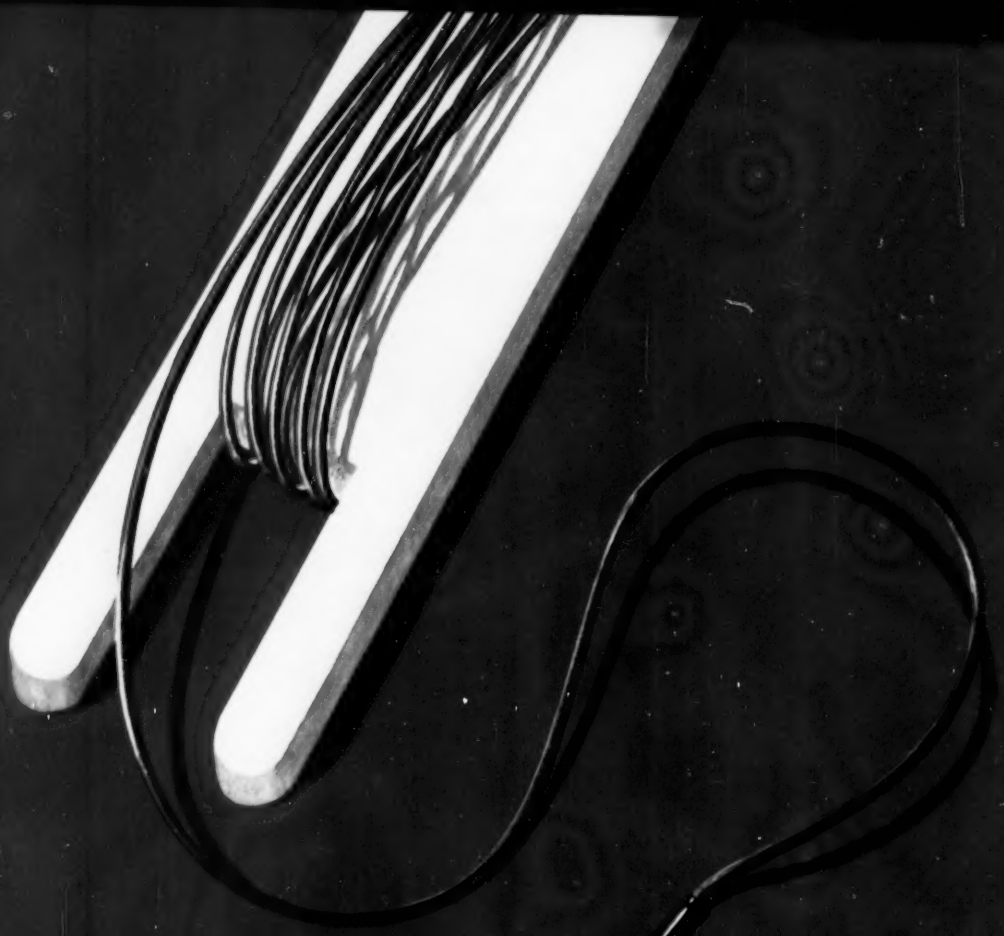

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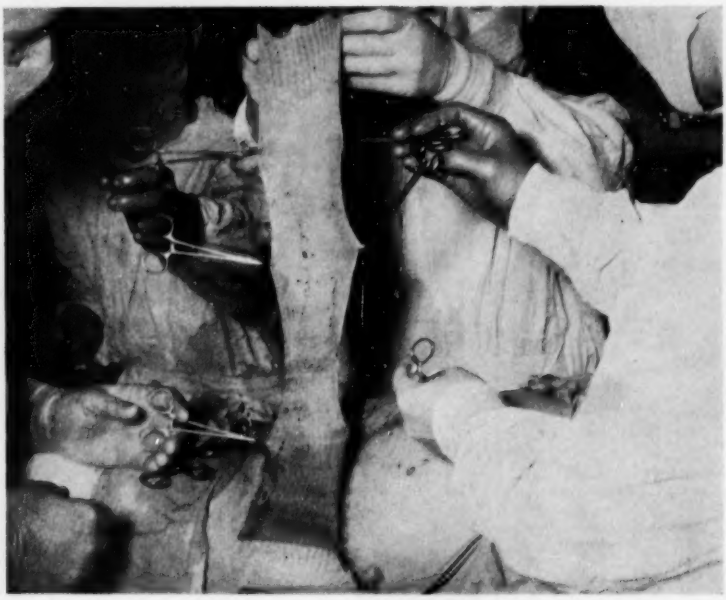

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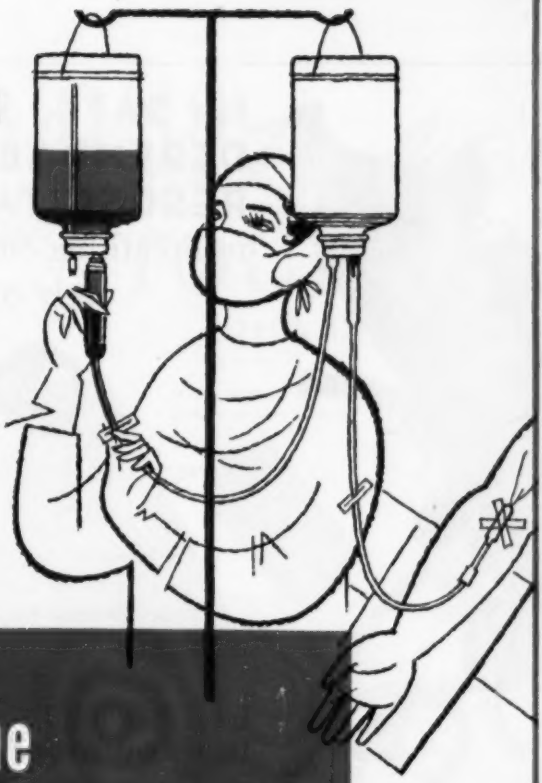

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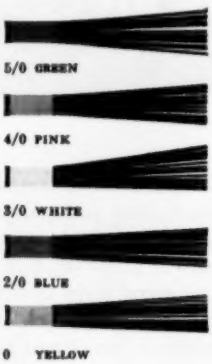

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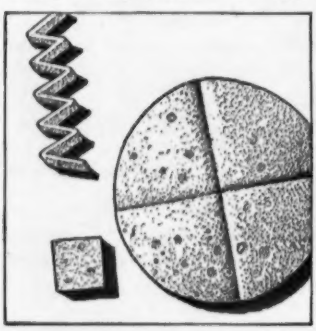

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VOLUME 68 MAY 1954 NUMBER 5

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Editorial

THE TREATMENT OF CANCER

HAROLD WOOKEY
TORONTO

NO ONE who is concerned with the treatment of cancer can feel satisfied with the present methods of dealing with this disease. We can only hope that research efforts in this great field of pathology may eventually throw some light on the cause or causes of malignant disease, with the result that cancer may either be prevented or at least attacked on a more scientific basis.

Surgical operations dealing with cancer are giving gratifying results provided the disease is localized and accessible and a diagnosis has been made early. The development of surgical technique, improvements in anesthesia, as well as in both preoperative and postoperative care, have made possible very radical procedures which, happily, not infrequently result in cure. Surgeons, however, should not be tempted to undertake the impossible or, indeed, as a result of their efforts leave the patient in such a condition that life is well-nigh intolerable. The age, the general condition, and even the temperament of the individual should be considered before undertaking treatment, for in some cases a disability such as the loss of the larnyx or a permanent colostomy would not be borne. Very radical surgical operations should be confined to those cases in which there is a hope of cure. Otherwise, palliative measures only would seem to be justified.

In the field of radiotherapy great advances have been made, both in technique and in equipment. The new cobalt radiation unit has been acquired by some treatment centers and, though still in the experimental stage, would seem to be a valuable agent in radiotherapy. Radiotherapy has been found to be specially effective in the treatment of certain types of cancer. This is true in cancer of the skin, in the so-called oral group of cases, and in the treatment of cancer of the cervix, uterus and breast. From many centers of radiotherapy encouraging reports are appearing.

The employment of radioactive substances and the use of hormones has proved to be of value in some cases. The effects of removal of both adrenal glands and of hypophysectomy are being studied, and these procedures would seem to be helpful in advanced cases of carcinoma of the breast.

It would appear that all these various methods of treatment should be carefully considered in the approach to a cancer problem. The combination of surgery with radiotherapy in many cases is likely to be more effective than either alone. It would seem desirable that when each case of cancer is seen in our hospitals it should be carefully studied and the best method of treatment agreed upon. It is important that

exact records be kept and that patients should be followed up at regular intervals. In large institutions, if at all possible, the treatment of cancer should be integrated with research projects.

One wonders whether the criteria of success in the management of cancer are not too severe. In follow-up studies results are evaluated in terms of cures over a five- or ten-year period, as the case may be. It is certainly gratifying to find patients who have been cured of cancer, but, unfortunately, there are many who are not.

Many incurable diseases are being treated palliatively with prolongation of life and the relief of suffering. The incurable cancer patient should be treated in the same way. Palliative treatment in some form may prolong life and relieve a great deal of suffering. We think that such service to these individuals is of the greatest importance. A grave responsibility rests not only on the specialist but also on the family physician, who is often called upon to care for incurable cases leaving our institutions. The family doctor should understand the problem and be willing to offer moral support to these individuals as well as to do everything possible to relieve unnecessary suffering.

HAROLD WOOKEY, M.D.

VOLVULUS OF THE CECUM

Emphasis on Possible Predisposing Lesions of the Left Colon

HUGH E. WILSON, M.D.
GERARD DESFORGES, M.D.
HERBERT G. DUNPHY, M.D.
AND
ALEXANDER J. A. CAMPBELL, M.D.
BOSTON

THE DIAGNOSIS and successful treatment of the relatively rare volvulus of the cecum gives great intellectual satisfaction. More important, however, proper recognition and early therapy may be lifesaving to the patient. It is not the purpose of this paper to review the literature on volvulus of the cecum. This has been well done by Chalfant,[3] Gardiner,[9] Sweet,[23] and Wolfer.[26] Nor is it our intent to merely add eight more cases of an unusual entity to those already published. We do, however, wish to emphasize a condition which occurs in several forms, all of which can be diagnosed if the condition is borne in mind. Further, we would point out that volvulus of the cecum may frequently be initiated by partially obstructive lesions of the left colon.

Emphasis is important in a disease which has shown such a high mortality in the past* and in which early diagnosis and treatment can usually avert a fatal issue. We feel, therefore, that a discussion of eight cases† personally known and treated by the authors may help in clarification of an often misdiagnosed condition.

ETIOLOGY

All writers on this subject are agreed that the primary cause of volvulus of the cecum is a congenital failure of normal fixation of varying portions of the proximal colon. As Gardiner[9] points out, these variations are due to alterations in the third stage of embryological rotation of the gut with or without a mesentery of the ascending colon. Usually the points of fixation around which rotation occurs are at the hepatic flexure or at the crossing of the duodenum.‡ Cadaver studies have revealed that approximately 10 to 25% of adults have sufficient cecal mesentery to allow volvulus.§

Formerly Teaching Resident, Fifth (Tufts) Surgical Service, Boston City Hospital (Dr. Wilson); Formerly Teaching Resident, First (Tufts) Surgical Service, Boston City Hospital (Dr. Desforges); Chief, Third Surgical Service, Quigley Hospital (Soldiers Home) Chelsea, Mass., and Surgeon, Newton-Wellesley Hospital (Dr. Dunphy); Clinical Professor of Surgery, Tufts College Medical School, and Surgeon-in-Chief, First Surgical Service, Boston City Hospital (Dr. Campbell).

* References 3 and 26.

† Case 6 previously reported.[4]

‡ References 7, 12, 15, and 16.

§ References 9 and 26.

Contributory causes leading to initiation of cecal volvulus have been summarized by Sweet [23] as follows:

1. Overeating, with or without violent physical activity.
2. Distention of cecum with feces and gas.
3. High roughage diets.
4. Vigorous peristalsis with drastic purgatives.
5. Pressure of enlarging uterus (pregnancy).
6. Violent coughing.
7. Diarrhea.
8. Incarceration of a dilated cecum in a hernia (especially umbilical).

Four of our eight cases gave a history of previous abdominal surgery, making it seem probable that previous surgery and resulting adhesive fibrous bands is another contributing factor. Also, four patients had partially obstructive lesions in the left colon; three had carcinoma and one a benign stricture which probably led to cecal distention and hyperactivity.

INCIDENCE

In the United States volvulus of the cecum is the least common of all forms of intestinal obstruction. Young, Morrison, and Wilson,[27] reporting seven cases of this entity, point out that there was only one case of cecal volvulus in 956 cases of intestinal obstruction at the Boston City Hospital during the years 1934 to 1943 inclusive. Further investigation shows that during the years 1944 to 1946 inclusive there were no cases of cecal volvulus found in 244 cases of intestinal obstruction at this hospital—an incidence of 0.083% for this 13-year period.

However, during this period a number of cases were diagnosed as "redundant cecum" by exploration or barium enema and exploration following recurrent attacks of right lower quadrant abdominal pain. This would seem to support Gardiner's [9] contention that there is "chronic cecal volvulus" which is characterized by repeated attacks of right lower quadrant pain, tenderness, and distention, suddenly relieved by the passage of large amounts of gas per rectum. Most of these cases so diagnosed were treated by plication or fixation of the cecum without further known attacks. Inglefinger [14] has also confirmed this finding.

The sex incidence of cecal volvulus has been reported almost exclusively as higher in males, with Gardiner [9] reporting the ratio as three to one. Interestingly, all of our cases have been females.

DIAGNOSIS

The closed loop character of volvulus of the cecum predisposing to rapid distention and perforation makes early diagnosis mandatory if the mortality is to be reduced.|| The organisms of the cecal contents, particularly the anaerobes, which multiply so rapidly under anoxic conditions, cause rapid distention of the cecal loop with perforation and secondary fatal peritonitis.[25] Wolfer,[26] reviewing the literature in 1942, reported 304 cases from the literature with an operative mortality of 50%. In addition, Wolfer and Chalfant[3] agree that lacking surgical intervention this condition is uniformly fatal. Obviously early diagnosis and proper surgical treatment is of prime importance if the mortality is to be reduced.

|| References 20 and 21.

Several writers have stated that diagnosis of cecal volvulus is rarely made before operation or autopsy.¶ This should not be the case. The diagnosis of acute cecal volvulus is not a difficult one, particularly with the aid of x-rays,# if the entity is considered.

The history is often typical. Many patients give a past history of episodes of crampy abdominal pain, distention, and temporary obstipation relieved suddenly with the passage of large amounts of foul-smelling flatus and loose stools per rectum. Previous abdominal surgery and a history of constipation are also extremely common.*

The attack responsible for the presenting complaint is usually of several days' duration and may have been preceded by a bout of heavy eating, "intestinal grippe," unusual exertion, or catharsis-induced diarrhea. The signs and symptoms are those of low intestinal obstruction, early, and later, those of closed-loop obstruction with strangulation.[23] Symptoms usually begin as colicky abdominal pain which is progressive and often localizes in the right midabdomen. The passage of a small amount of feces and gas present in the colon at the time of onset does not obviate the diagnosis since obstipation soon becomes apparent. Fecal vomiting may not be manifest for two or three days and occurs as the volvulus produces small bowel obstruction at the terminal ileum. As strangulation ensues the pain becomes constant.

Examination reveals the patient in a state of dehydration and in varying degrees of discomfort. Older patients particularly may have relatively asymptomatic intervals. The abdomen is distended. A large tympanitic mass is apparent and usually located in the upper abdomen. This may or may not be tender, depending upon the stage of the disease. Absence of palpable or percussable cecum in the right iliac fossa is to be expected. Gastric intubation and suction will differentiate the distended organ from the stomach.

Next to awareness of the volvulus of the cecum as a clinical entity, x-ray study is probably the greatest single aid in diagnosis. Flat and upright abdominal roentgenograms are quite typical. McGraw [18] has pointed out that the criteria necessary for diagnosis are present in the simple film of the abdomen. He has outlined these as follows:

1. Cecum greatly dilated and appears to lie in an ectopic position.

2. Loops of small bowel may be seen distended with gas and often lying to the right of the distended cecum.

3. The ileocecal valve may be demonstrated lying to the right of the distended cecum. It will give a distinct shadow in contrast to the gas in the cecum surrounding it and the gas in the small bowel within it.

4. The spiral distortion of the mucous membrane folds may sometimes be seen at the site of twisting, being visible because of contrast with gas in the bowel.

5. There is usually a considerable dilatation of the small bowel with fluid levels in the upright position, suggestive of small bowel obstruction.

6. Usually there is a single fluid level in the distended colon. (In volvulus of the sigmoid there is usually no distention of the small bowel and two fluid levels in the distended loop can be seen in most instances.)

¶ References 2, 15, and 22.

References 8, 14, and 17.

* References 5 and 19.

Barium studies are not necessary but may support the diagnosis. A barium swallow will show the stomach behind the distended loop when the cecum is in the upper abdomen, and barium enema may show the twisted mucosal folds at the site of torsion in the ascending or transverse colon.

REPORT OF CASES

CASE 1.—L. G. (N-W H. 0-10008). This 46-year-old, white, mentally deficient woman was admitted on Aug. 21, 1948, with the chief complaint of abdominal pain and obstipation of approximately one week's duration. The pain had become worse during the two days prior to admission and she had vomited once the night prior to admission. Because of her mental status no past history could be obtained.

Examination of the abdomen showed marked distention. There was moderate tenderness to palpation throughout. No definite mass was palpable. Peristalsis was hypoactive, with an occasional high-pitched tinkle. The rest of the physical examination was essentially negative.

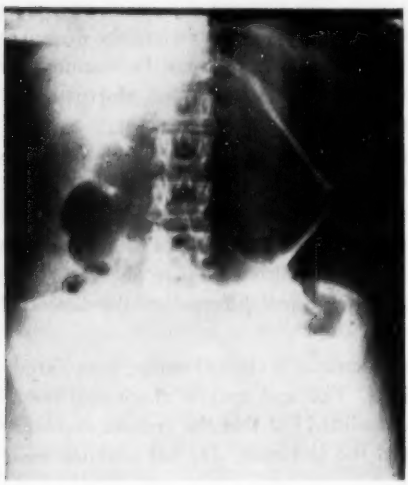

Fig. 1 (Case 1).—Abdominal flat plate, showing huge dilated cecum in left upper quadrant and midabdomen.

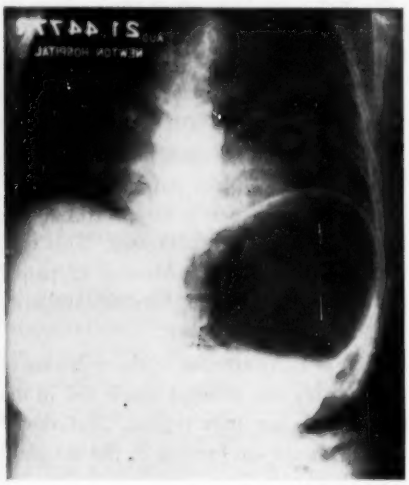

Fig. 2 (Case 1).—Abdominal upright x-ray, showing dilated cecum in left upper quadrant with large fluid level.

X-ray examination (Fig. 1) revealed a markedly distended single loop of bowel with haustral markings in the left upper quadrant of the abdomen. A fluid level was noted on the upright film (Fig. 2). Barium enema was performed and the barium passed to the distal portion of the transverse colon. A preoperative diagnosis of volvulus was made, and exploration was done.

On opening the abdomen, a large dilated loop of colon was found. It was extremely tense and a constriction could be felt at its base. Partial decompression was carried out, and the cecum and appendix were identified in the left upper quadrant. It was decided to resect the dilated loop since it did not appear possible to determine the pathology and return the cecum to the abdomen.

After resection of the terminal ileum, cecum, and transverse colon, it was discovered that there was a defect in the transverse mesocolon through which the small bowel, cecum, and much of the transverse colon had herniated into the lesser peritoneal cavity. This bowel mass had then passed through the foramen of Winslow and undergone torsion. There was considerable hypertrophy of the cecum, and it was felt that the abnormal position of the bowel had been present

for some time. The small bowel was returned through the foramen of Winslow and the transverse mesocolon, and the defect in the latter was closed. An end-to-end ileo-transverse-colon colostomy was performed.

Convalescence was uneventful, and the patient was discharged on Sept. 8, 1948.

CASE 2.—L. W. (B. C. H. 1346105). This 50-year-old nurse entered Jan. 6, 1950, complaining of continuous periumbilical and lower abdominal pain of six hours' duration. The pain did not radiate, nor was there any associated nausea. The last bowel movement had taken place one day prior to admission and was thought to have been normal.

The past history revealed that four years prior to admission a hysterectomy had been performed and two years previously she had been hospitalized because of intermittent abdominal distention of many years' duration. Crampy lower abdominal pain was invariably associated with the attacks of distention. During the latter admission a laparotomy was performed and "the distended and hypertrophied cecum and ascending colon" were repositioned without fixation.

Fig. 3 (Case 2).—Abdominal flat plate, showing dilated cecum in left upper quadrant with dilated terminal ileum and ascending colon.

One year prior to the present admission the patient reentered with signs and symptoms of small bowel obstruction which were relieved by intubation.

Physical examination revealed a markedly apprehensive middle-aged woman. The entire examination was negative except for slight abdominal distention and hypoactive peristalsis to auscultation. There was no abdominal tenderness or spasm. Two well-healed laparotomy scars were found on the lower abdomen.

Laboratory examinations were negative except for the x-rays of the abdomen which revealed an enormously distended loop of bowel in the left upper quadrant (Fig. 3).

A diagnosis of intestinal obstruction was made, and immediate laparotomy revealed a volvulus of the terminal ileum and entire ascending colon which was gangrenous. Resection and end-to-end ileo-transverse colon anastomosis was done. Convalescence proceeded uneventfully, and the patient was discharged on the thirteenth hospital day. She has remained asymptomatic.

CASE 3.—L. S. (B. C. H. 1372134). On Sept. 7, 1950, this 73-year-old white widow was admitted with the chief complaint of generalized crampy abdominal pain of four days' duration. Loud "gurgles" had been heard in the abdomen preceding the pain.

She had been chronically constipated for at least 20 years and had taken daily laxatives "to keep her bowels open." During the four days prior to admission she had had no bowel movements, and the abdomen had gradually become more distended. There had been no nausea or vomiting. A right nephrectomy had been performed 20 years previously for unknown reasons.

Physical examination revealed a well-nourished, elderly white woman in no acute distress. The examination was essentially negative except for the abdomen which was greatly distended and tympanitic with hyperactive, high-pitched peristaltic rushes. There was fullness in the right lumbar region about an old right nephrectomy scar.

Initial laboratory work showed albuminuria and a white blood cell count of 14,000.

A Harris tube was passed and intravenous fluids were administered. Abdominal x-rays showed a single dilated loop of large bowel lying transversely in the midabdomen and an empty right iliac fossa.

A diagnosis of volvulus of the cecum was made, and a laparotomy was done on the day after admission. The cecum and ascending colon were found dilated and lying in the midabdomen. They were dusky red in color and there were numerous rents in the serosa. A fibrous band between the medial portion of the cecum and the region of the hepatic flexure was divided. This permitted a sudden clockwise detorsion of the cecum, but at the same time a rent was noted in its medial wall. There was spillage of much foul-smelling cecal contents. The rent was closed and a cecostomy performed. Exploration revealed no other cause for obstruction. The postoperative course was uneventful. The cecostomy did not close, and on Oct. 20, 1950, a barium enema was performed, which revealed an area of narrowing in the low sigmoid consistent with carcinoma. Sigmoidoscopy revealed a firm narrowing lesion with apparently intact mucosa. On Oct. 26, 1950, an anterior resection of the rectosigmoid was performed. The pathological report showed diverticulosis, diverticulitis, and stricture with a small polypoid submucous lipoma and melanosis coli. Her postoperative course was uneventful, and on Nov. 14, 1950, the cecostomy was closed. She was discharged 10 days later.

Case 4.—M. S. (N-W H. 51-2810). This 62-year-old white woman entered March 7, 1951, with the chief complaint of "grippe" of two weeks' duration. There was associated nausea, vomiting, and abdominal pain for the four days prior to admission. The past history was noncontributory.

Physical examination revealed an elderly woman in no acute distress. The positive findings were limited to moderate distention and generalized tenderness of the abdomen. Peristalsis was absent.

Flat and upright films of the abdomen revealed a single, huge, dilated loop of bowel with a fluid level.

A diagnosis of intestinal obstruction was made, and the possibility of volvulus of the cecum was mentioned as the obstructing mechanism. At laparotomy the day after admission a markedly dilated cecum was found in the left upper quadrant. It had rotated 120 degrees in a clockwise fashion about a band to the midportion of the ascending colon. A resection of the cecum, ascending colon, and terminal ileum with end-to-end ileo-transverse colon colostomy was carried out.

The postoperative course was uneventful, and the patient was discharged on the twelfth day of her convalescence.

Case 5.—A. M. (N-W.H. 51-3844). This 92-year-old white woman was admitted on April 4, 1951, with chief complaint of pain and distention of the abdomen of 48 hours' duration.

The patient had been relatively well for the previous four years following resection of the descending colon for cancer with complete obstruction. During the year prior to admission there had been several brief bouts of distention, associated with constipation relieved by enemas. The current episode had been more severe and persistent than the others and the night of entry she became somewhat nauseated.

Physical examination revealed a well-developed, well-nourished elderly woman in moderate discomfort. There were a few transient rales at both lung bases and cardiomegaly with a systolic murmur. The remaining physical examination was not remarkable, except for the abdomen, which was hugely distended, quite soft, and nontender. Peristalsis was of apparently normal character in frequency and pitch with occasionally extremely loud rushes, audible without a stethoscope.

On admission a Miller-Abbott tube was passed with slight relief of the distention. Three days after admission there were copious, watery bowel movements, and the general condition of the patient remained good. She was started on a liquid diet, by mouth.

Laboratory work on admission revealed the following: hematocrit 43%; hemoglobin 14.6 gm. per 100 cc.; white blood cells 12,600. The latter rose steadily to 28,000 on the fourth hospital day, at which time operation was advised. Repeated flat films showed persistence of a huge dilated mass of bowel suggestive of cecum. A diagnosis of "intestinal obstruction, possibly volvulus of the cecum," was made, and on the fourth hospital day laparotomy was performed. A tremendously dilated cecum twisted twice around a band of mesentery, connecting the ascending colon to the abdominal wall, was encountered. The cecum, terminal ileum, and ascending colon were resected and an end-to-end ileo-transverse colon colostomy performed.

The patient did well immediately after the operation, but on the third postoperative day, she showed rather sudden signs of respiratory failure with a fall in blood pressure and cyanosis. Chest films revealed bilateral pulmonary basal congestion. She continued downhill and died.

Fig. 4 (Case 6).—Abdominal flat plate, showing large dilated cecum filling midabdomen and abdominal fluid from perforation.

Fig. 5 (Case 6).—Air contrast barium enema study, revealing partially obstructing polypoid lesion of left colon.

Postmortem examination showed no complications at the operative site. Bilateral bronchopneumonia and a small undiscovered carcinoma of the descending colon, apparently unrelated to her previous carcinoma of the sigmoid were found.

Case 6.—S. Mc. (B. C. H. 1418699). This 73-year-old woman entered on Nov. 28, 1951, with the chief complaint of lower abdominal crampy pain of six days' duration. Two days prior to admission two enemas were taken without relief. The pain became worse, and there began repeated episodes of vomiting. The past history was noncontributory. There had been no previous similar episodes or operations.

Physical examination revealed an elderly, acutely ill woman in marked distress. The temperature was 100 F., the pulse was 120 beats per minute, and respirations were 40 per minute. The blood pressure was 140 mm. of mercury systolic and 90 mm. of mercury diastolic. The abdomen was markedly distended and everywhere tympanitic. There was also diffuse tenderness.

Laboratory studies revealed findings consistent with marked dehydration and mild alkalosis. X-rays of the abdomen in the upright, left lateral decubitus and supine positions were suggestive of cecal volvulus with perforation. (Fig. 4).

Operation was carried out immediately with detorsion of the volvulus and tube cecostomy for decompression. A small 0.2 cm. area of devitalization, presumably the point of perforation, was closed also. Chlortetracycline (Aureomycin) was given postoperatively for four days.

Barium enema studies done postoperatively revealed an intussuscepting polypoid mass of the descending colon (Fig. 5). This was segmentally resected eight weeks after the original operation. Convalescence was uneventful, and the patient was discharged with a small fecal fistula in her initial laparotomy wound 10 weeks after admission. The fecal fistula persisted because of complete epithelialization, so six months after the original operation a right colectomy and ileotransverse colon colostomy were done. The patient has been asymptomatic since.

Case 7.—C. M. (B. C. H. 1419078). This 63-year-old woman entered, via the outpatient department, on Dec. 1, 1951, with the chief complaint of attacks of generalized abdominal cramps with occasional nausea and vomiting of four years' duration. The past history revealed an appendectomy done 15 years prior to admission and a cholecystectomy done 2 years previously.

Fig. 6 (Case 7).—Barium enema study, showing position of twisted cecum in this case of "chronic" volvulus of the cecum.

Physical examination was entirely negative except for the healed abdominal wounds.

The laboratory findings were not remarkable except for barium enema studies which revealed that the "cecum lies high in right abdomen" (Fig. 6).

Exploration was carried out with the diagnosis of chronic cecal volvulus with intermittent episodes of intestinal obstruction. The cecum and proximal two-thirds of the ascending colon were rotated upward so that the posterior aspect of the cecum presented when the abdomen was opened. In addition, the abnormally placed portion of colon was found rotated 180 degrees to the patient's left. Mobilization of the right colon and cecopexy were carried out. Convalescence was uneventful and patient has remained asymptomatic.

Case 8.—E. M. (N-W. H. 52-3324). This 78-year-old white woman was admitted on March 19, 1952, complaining of constipation, abdominal distention, and abdominal pain.

The patient believed she had had a "virus attack" about one week prior to admission, but had little fever at that time. She began to have crampy right lower abdominal pain. Two days before admission this was associated with nausea and vomiting. She had not moved her bowels during the previous four days in spite of an enema two days previously. She stated her abdomen had

been somewhat distended for three weeks and that she had always been "gassy," but that this episode was the worst. Six months before she had had a barium enema, which she stated showed diverticulitis.

Past history revealed a cholecystectomy and appendectomy at the age of 53 years. Two years prior to this admission pernicious anemia was diagnosed. Her appetite remained good, but she had been having increasing difficulty with constipation, "gas attacks," distention, and cramps.

Physical examination revealed a pale elderly woman in moderate distress. The abdomen was greatly distended and tympanitic. There was a large mass in the upper abdomen extending to the left. The abdomen was slightly tender and there was no peristalsis heard.

The laboratory studies on admission showed anemia and dehydration with a white blood cell count of 14,000. Abdominal x-rays showed "enormous dilatation of the large bowel, probably cecum displaced toward the midline, extremely suggestive of volvulus of the cecum." Barium enema substantiated the clinical and x-ray diagnosis.

Three transfusions were given, and the patient was hydrated with intraveous fluids. On the day following admission she was operated on, with a preoperative diagnosis of "volvulus of the cecum." A clockwise cecal volvulus was found with the point of fixation being an adhesive band over the midportion of the ascending colon. The cecum was edematous, with doubtful viability. The terminal ileum, cecum, ascending and right half of the transverse colon were resected and an end-to-end ileotransverse-colon colostomy was performed.

After operation the patient had an episode of profound circulatory collapse with marked Cheyne-Stokes respirations and a respiratory rate of 6 to 8 per minute. She was given intravenous fluids until the fifth postoperative day. After this she was fed by gastric gavage and was given an enema, following which she had loose stools. She developed cardiac decompensation, and on the eighth postoperative day became anuric, and died on the ninth postoperative day.

Autopsy showed the anastomosis well healed and functioning. The lungs revealed severe bronchopneumonia. There was a small nonobstructing carcinoma of the midsigmoid involving one side of the lumen.

TREATMENT

No set surgical procedure can be proposed for treatment of volvulus of the cecum. Choice of the proper operation depends on the condition of the patient and of the abdominal contents at the time of laparotomy. The first step is detorsion of cecum, but this alone is probably not enough, since cases of recurrence following simple detorsion alone have been reported. This situation probably obtained in Case 2. Many procedures have been suggested including cecopexy or plication of the cecum, fixation of the cecum to the abdominal wall by suture or a flap of parietal peritoneum, cecostomy, Mikulicz type resection or exteriorization of the involved bowel and primary resection of the involved segments and ileotransverse colon anastomosis.† The latter procedure is the one of choice since the hospital stay is considerably shortened and chance for recurrence eliminated. However, it is the most formidable of the procedures mentioned and can be used only if conditions permit. In seven cases reported by Young and co-authors,[28] four were treated with a Mikulicz type resection. For these patients the average hospital stay was over 76 days. Nevertheless, this may be the procedure of choice in a very ill patient with nonviable bowel. In our three cases successfully resected primarily with ileo-transverse-colon anastomosis the average hospital stay was 14 days.

SUMMARY

All of our cases but one were of the acute variety. We include the case of recurrent or chronic volvulus because of the strong clinical and x-ray evidence and because surgery completely relieved the patient's symptoms.

† References 1, 2, 6, 10, 11, and 13.

Summary of Eight Cases of Volvulus of Cecum

Case No.	Patient	Age	Sex	History of Previous Attacks	Previous Abdominal Surgery	Left Colon Pathology	X-Ray Location of Cecum	Preoperative Diagnosis	Operation Performed	Outcome
1	L. G.	46	F	No history available	0	0	L. U. Q.	"Volvulus"	Resection and ileo-transverse colostomy	Living and well
2	L. W.	50	F	+	+	0	L. U. Q.	Intestinal obstruction	Resection and ileo-transverse colostomy	Living and well
3	L. S.	73	F	Suggestive	Right nephrectomy	Benign stricture	Midabdomen	Volvulus of cecum	Cecostomy (ant. resection of left colon)	Living and well
4	M. S.	62	F	Suggestive	0	0	L. U. Q.	Intestinal obstruction (volvulus of cecum suggested)	Resection and ileo-transverse colostomy	Living and well
5	A. McL.	92	F	+	+	Carcinoma	L. U. Q. and midabdomen	Intestinal obstruction; ? volvulus of cecum	Resection and ileo-transverse colostomy	Died 4th post-operative day, bronchopneumonia
6	S. McC.	73	F	0	0	Carcinoma	Most of abdomen	Volvulus of cecum	Cecostomy (left colectomy)	Living and well
7	C. M.	63	F	+	+	0	R. U. Q.	Chronic volvulus of cecum	Cecopexy	Living and well
8	E. M.	78	F	+	+	Carcinoma	Upper midabdomen	Volvulus of cecum	Resection and ileo-transverse colostomy	Died 9th post-operative day, bronchopneumonia

It is interesting to note that, although the literature indicates that volvulus of the cecum is a disease of young adults, our patients' age range was from 46 years to 92 years. Previous papers indicate that the disease occurs considerably more often in males. All eight of the cases in this series were females.

Four of the eight gave definite histories of previous similar attacks and two others had past histories strongly suggestive of previous episodes. Four of the patients had had previous abdominal surgery and one other a right nephrectomy in the past.

A point that should be emphasized is that four of these eight cases had coexisting left colon pathology which we believe was the predisposing factor leading to the cecal volvulus. This evidence would strongly suggest that in any case of volvulus of the cecum left colon pathology should be suspected and the patient should be investigated with that possibility in mind after the acute problem has been remedied. This feature does not seem to have been adequately stressed previously.

In the seven acute cases reported, a diagnosis of volvulus of the cecum was entertained preoperatively in five, was suggested in one, and the unqualified diagnosis of "intestinal obstruction" was made in another. In all eight cases the essential criteria were present and the diagnosis could have been made preoperatively had we been more alert to the possibility.

Two of the eight patients died postoperatively with bronchopneumonia proved at autopsy, one on the fourth and one on the ninth postoperative day. These were the two oldest patients. One was 92 years old, the other 78 years old. The six living patients have been completely relieved of their symptoms (Table).

CONCLUSIONS

Volvulus of the cecum is a relatively rare condition which in the past has shown an extremely high mortality. The diagnosis can be made if the surgeon is aware of the entity.

An abnormally mobile right colon is a prerequisite for the disease and is not uncommon. Other contributory etiological factors are reviewed.

The clinical picture is usually typical. Awareness of the condition and abdominal x-rays are the two most important diagnostic aids.

Eight cases of volvulus of the cecum are reported with a mortality of 25% (Table). Both deaths were due to bronchopneumonia proved at autopsy.

It is stressed that any case of volvulus of the cecum should be investigated for obstructive left colon pathology since this may be a predisposing factor to the volvulus and may be an otherwise overlooked carcinoma.

The treatment of choice depends upon the condition of the patient and the condition of the bowel at the time of surgery, but simple detorsion is probably not adequate.

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PEPTIC ULCER PERFORATIONS

Statistical Study of Cases in Albany Hospital 1935 to 1951 Inclusive

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THIS REPORT represents a statistical study of perforated peptic ulcers which have occurred in the Albany Hospital during the years 1935 to 1951 inclusive. Its purpose was to review the subject from the following angles: methods of treatment, location of the perforations, time consumed between the time of entering the hospital to the time of operation, the mortality and the time of operation, number of cases reoperated upon at the Albany Hospital, causes of deaths, positive past histories, relation of mortality rate to the introduction of antibiotics, and general mortality rate. These cases represent only those having general peritonitis with perforation. So-called chronic perforations are not included in this survey.

Type of Operation with Mortality *

	Patients, No.	Deaths	
		No.	%
Suturing with drainage	54	11	20.3
Suturing without drainage	61	2	3.2
Suturing with gastrojejunostomy	15	5	33.3
Excision of ulcer	1	1	100
Drainage alone	5	3	60
Total	136	22	16.1

* Exploration was done in one case, but no ulcer was found.

Opinion varies as to the method of treatment in these cases. Recent data, though anteceded by many, show that the upswing toward primary subtotal gastrectomy is taking a prominent place. Primary suture, omental inlay, or a combination of the two, followed subsequently, if necessary, by subtotal gastrectomy still is the treatment of choice by many surgeons. From our records at the Albany Hospital, conservative surgery has been, on the whole, our procedure.

There was a total of 146 cases—136 operative and 10 nonoperative (autopsied). Roentgenograms were positive in 41, negative in 12. There was a negative preoperative history in 31, while 109 gave a positive history. Six were too sick for the taking of a history. The average white blood cell count was 14,390, some patients having leucocytosis with a high count, while a few showed a normal count.

In our series of 136 operations, primary suture with or without omental inlay was employed either with or without drainage in 116 cases; gastroenterostomy, in 15 cases; excision of the ulcer, in 1 case, and drainage alone, in 4 cases. In the 54 cases with suturing and drainage there was a mortality rate of 20.3%, while in the 62 without drainage the mortality was 3.2%. No definite conclusions can be reached as to why the percentage is so much higher in those cases with drainage,

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unless it is assumed that the cases appeared severer. In 15 cases in which suturing and gastroenterostomy were employed there was a mortality of 33.3%.

The location of the perforations in both operative (136) and nonoperative (10 autopsied) cases was as follows: Seventy-three appeared in the stomach, 56 being prepyloric; 3 in the lesser curvature; 1 in the midportion; 1 in the gastric area, and 10 at the pylorus; 73 appeared in the duodenum: 56 in the anterior first portion; 3 in the posterior wall; 1 in the second portion, and 13 in the "duodenal area." One perforation was located in the old site of a former gastrojejunostomy.

An exporatory procedure was employed in one case, but no ulcer was found. From the above, it should be noted that no gastrectomy accompanied the procedure.

The time from onset of the acute symptoms to operation with the mortality rate may best be shown by the following tabulation:

Hours	Cases, No.	Deaths	
		No.	%
0- 3	105	10	10.5
4- 6	14	0	0
7-10	3	1	33.3
11-15	3	2	66.6
16-20	3	3	100
21-24	3	2	66.3
25-48	2	2	100
Days	2	2	100
?	1	0	0
Total	136	22	16.1

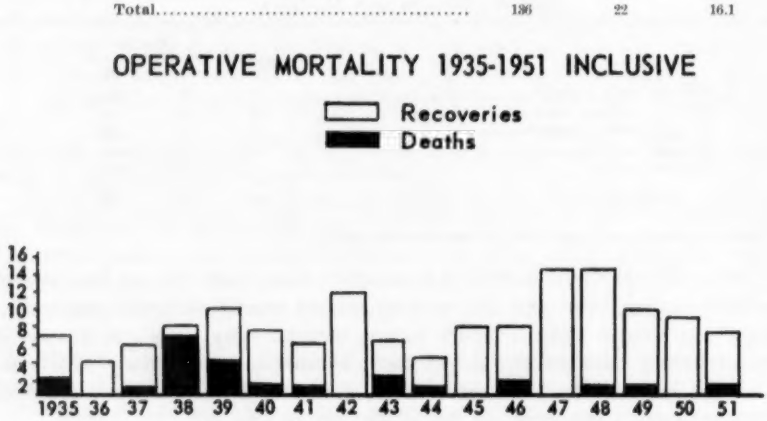


Chart 1.

Postoperative complications numbered 17: pneumonia 7; pulmonary embolism 1; subhepathic abscess 1; phlebitis 1; evisceration 1; gastric hemorrhage 1; cardiorenal 1; coronary 2; trauma 1, and not recognized 1.

CASES WITH REOPERATION (ALBANY HOSPITAL)

Subtotal gastrectomy was done in 5 cases; resuturing in the same location, in 1 case; postgastrojejunostomy, in 3 cases; postgastrojejunostomy and bilateral vagotomy, in 1 case; drainage of hepatic abscess, in 1 case; drainage of subhepatic abscess, in 1 case; drainage of subphrenic abscess, in 1 case; drainage of pelvic abscess, in 1 case, and suturing for evisceration, in 1 case, the total number of reoperations being 15.

In the years 1935 to 1939, inclusive, there was a mortality rate of 41.9%. In the years 1940 to 1944, the mortality rate was 15.6%; in 1945 to 1949, the mortality rate was 5.2%, and in the years 1950 to 1951, the mortality rate was 6.2%. There were 22 operative deaths of the 136 patients operated upon—a final mortality rate of 16.1%.

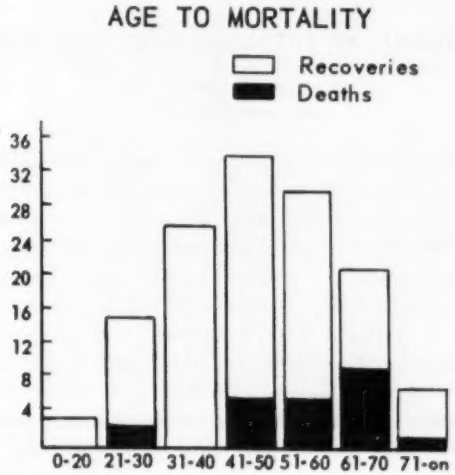


Chart 2.

CONCLUSIONS

This survey emphasizes the following facts:

1. That conservative surgery still has its place in the treatment of acute perforations of peptic ulcers with general peritonitis and that primary suturing, preferable with omental inlay, can be and, where obstruction is not present, still may be considered good practice.

2. That the mortality rate has very markedly diminished since the introduction of antibiotics, as illustrated in our series.

3. That all cases should be operated upon once they have received antishock treatment and treated postoperatively with antibiotics and intelligent management of fluid intake—especial attention being paid to electrolytic balance.

4. That primary subtotal gastrectomy may be the treatment of choice, depending upon the surgeons' feeling on the subject, but that conservative operative treatment should not be discarded.

5. That elective secondary gastrectomy should in most cases be considered after a period of from 10 to 12 weeks. In our series only five patients presented themselves at our hospital for subtotal gastrectomy.

I do agree that primary subtotal gastrectomy is indicated in those who may be operated upon early and who have not responded well to medical treatment, especially if in good condition for operative procedure.

TREATMENT OF PILONIDAL CYST AND SINUS

J. MURRAY BEARDSLEY, M.D.
PROVIDENCE, R. I.

A GREAT diversity of procedures continue to be recommended for the cure of pilonidal cyst and sinus. Although differing in technical details, it is reassuring to note that there has been a trend away from the more complicated types of operations which involve transposition of muscle bundles and the use of pedicle flaps.

As we view our attempts to successfully excise a relatively small cyst and allowing for the unusual contours of the pilonidal region, it is little short of amazing that the results have been so unsatisfactory, even when a sinus is present and a low-grade infection complicates the picture. In other parts of the body presenting a similar problem, nothing other than a permanent good result would be expected. However, one can readily visualize healing problems in any area where a large segment of tissue has been excised and closure is associated with tension on wound edges.

Earlier ideas of treatment were based upon the principle that "recurrence" was due to residual pathological tissue which had not been completely removed at the initial operation. This naturally led to more radical operations, some of which included removal of the tip of the coccyx. Through the years, there has been a greater appreciation of fundamental principles, and, whether dealing with the open or closed method, most authors at least agree that conservation of normal tissues is a most important factor. It has come to be realized that "recurrence" is more apt to result from tissue waste and problems of healing in a difficult area. With this in mind, more emphasis is being placed on these very essential points. In spite of this, one is continually impressed with the fact that this concept is not taken too literally. The use of a relatively large elliptical incision is still a common practice, and the fairly popular use of marsupialization of skin to sacral fascia admits at once that tissue loss has been too great to carry out a normal closure in layers.

If a "blind" operation is carried out without knowing the size and extent of the cyst and the location and direction of possible sinus tracts, it is obviously impossible to accomplish complete removal without unnecessary sacrifice of normal tissue. Therefore, the initial step should be a careful inspection of the interior of the cyst through a simple incision, wiping it out thoroughly and determining at the outset its landmarks and the presence or absence of sinus tracts. If the latter are present, they should be exposed in a similar manner. The pathological tissue having now been completely exteriorized, its removal becomes greatly simplified and can be carried out with minimal tissue loss.

The dissection is facilitated by applying Kocher clamps to the cut edges of the incision on either side and making secondary incisions not more than 5 mm. from the original midline incision. With one finger in the sac as a guide, dissection of the

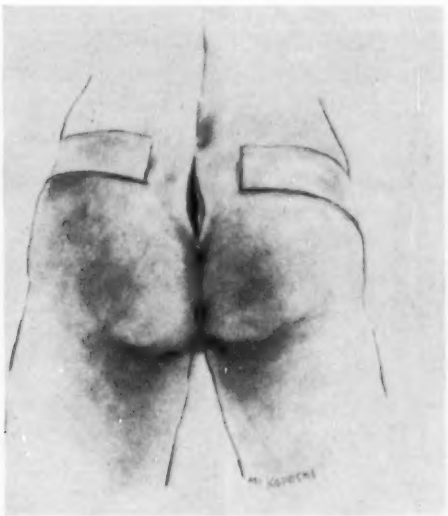
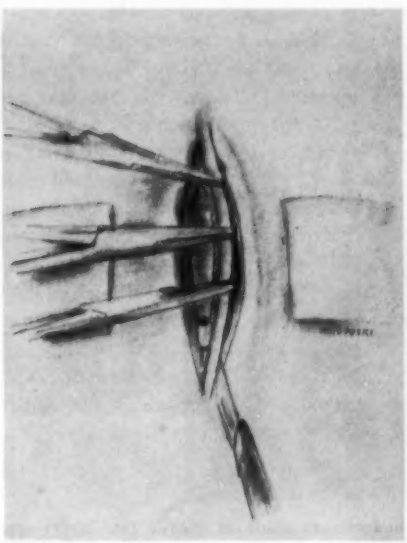
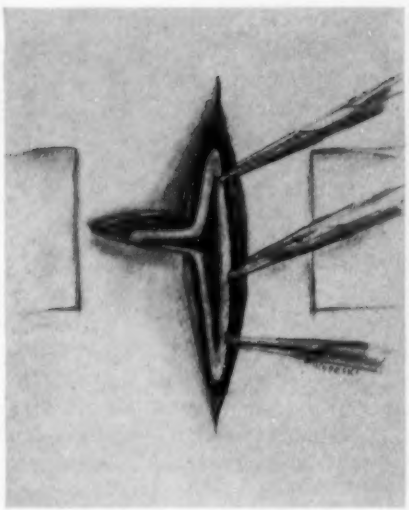


Fig. 1.—The cyst or sinus is incised in the midline in order to expose the interior of the sac, after which the contents are evacuated and the interior wiped clean with plain gauze. If sinus tracts are present, they are also exposed.



Figs. 2 (left) and 3 (right).—With Kocher clamps applied to the cut edge, a secondary incision is made 5 mm. lateral to the original incision. With a finger in the sac, careful sharp dissection is carried out on all sides of the specimen, down to the sacral fascia.



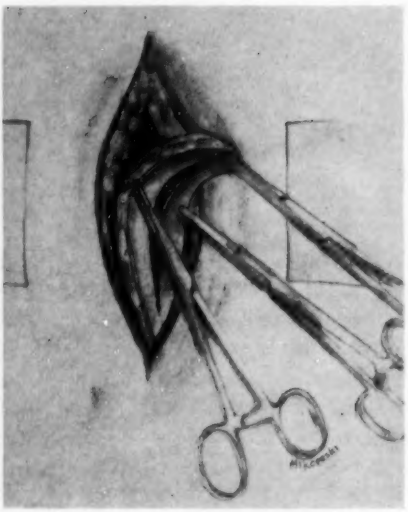


Fig. 4.—The sac has been completely mobilized except for its deep attachment.

Fig. 5.—The sac is being dissected from its bed. As a rule, the forefinger is also kept within the sac to facilitate this step.

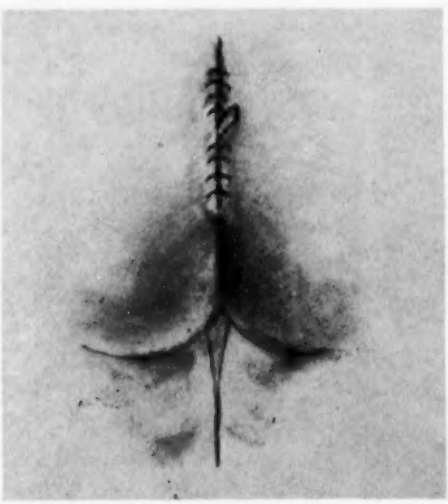


Fig. 6.—The adhesive straps are removed and closure made in one or two layers after thorough flushing with isotonic sodium chloride solution. A solution of penicillin and streptomycin is introduced into the wound as the closure is being made. One small rubber tissue drain is inserted.

cyst is quickly and easily accomplished and the same principle is applied in dealing with sinus tracts that may be present. This technique allows one to be quite certain that practically all normal tissue is preserved, and thereafter healing presents no serious problem. With the removal of the adhesive traction from the buttocks, the wound falls together without tension. Closure becomes a more or less individual problem, and, although through-and-through sutures which include the sacral fascia may be used, this is not absolutely necessary and the wound may be closed in layers.

The presence of a mild infection should be accepted, and, for this reason, a small rubber tissue drain is left in place for four or five days, as one is inclined to do in similar circumstances elsewhere. It has been my practice to introduce a solution of penicillin and streptomycin into the wound at the time of closure and to continue antibiotic therapy for three days. In no instance has a frank wound infection occurred.

The postoperative care is of the utmost importance and should always be carried out by the surgeon himself, since minor problems of wound healing in this region may not be sufficiently appreciated by those with limited surgical experience. Careful shaving about the incision should be continued until healing is complete.

SUMMARY AND RESULTS

This communication is not presented for the purpose of enunciating new principles but rather to describe a method by which those that have already received wide acceptance may be more effectively carried out. In my opinion, these two basic principles of adequate exposure of the disease and minimal loss of normal tissue can both be most effectively accomplished by a technique that gives exposure to both surfaces of the sac.

The above method has been applied to 27 consecutive private patients over a five-year period with no recurrences. Primary healing occurred in all but two, and these were of a minor nature. One case which had had two previous recurrences and a recently drained abscess had superficial wound infection which delayed complete healing for three weeks. The patient has now been observed for 14 months since healing occurred. The second delay was due to improper apposition of skin edges and although minor in degree, it persisted for four weeks and illustrates the importance of accurate skin approximation.

The length of follow-up is as follows: less than six months, three; six months to one year, five; one to two years, seven; two to three years, three; three to four years, three; four to five years, two and over five years, four.

Of the total number, 23 had draining sinuses at the time of operation and 3 had had previous excisions. The remaining four presented a simple sac without infection.

The average postoperative hospital stay was 5.1 days.

ACUTE OBSTRUCTION OF THE SMALL INTESTINE

Analysis of 154 Cases

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NOTWITHSTANDING advances in fluid and electrolyte balance,* antibiotics, gastrointestinal suction, and improvements in surgical techniques, the mortality of acute intestinal obstruction is still relatively high.† Up until the last few years the mortality rate was reported to be between 15 and 20% in many leading surgical clinics of this country (Table 1). In spite of much experimental and clinical work on the subject, many questions remain unanswered, and this disease remains a major problem in surgery.[14] In attempting to lower the mortality rate in this condition it is desirable to analyze such series of cases, seeking the answers to such questions as these: (*a*) How can an early and accurate diagnosis be made? (*b*) Can a distinction be made between a simple obstruction and one with early strangulation? (*c*) How frequent and important is the factor of strangulation? (*d*) What additional factors contribute to the high mortality? (*e*) When is nonoperative treatment preferable to immediate surgical intervention and vice versa?

TABLE 1.—*Mortality Rates in Reported Cases of Acute Small Intestinal Obstruction*

Year	Author	No. of Cases	Mortality Rate, %
1938	Wangensteen	157	17.9
1938	Scudder	2,150	24.0
1940	McKittrick and Sarris	136	20.0
1940	Schlicke, Bargen and Dixon	133	21.8
1942	Dennis and Brown	48	13.0
1943	Dennis and Brown	110	15.5
1944	Dennis	53	15.1
1946	Moses	118	8.4
1947	Hendricks and Griffin	168	27.9
1950	West and Schetlin	177	16.3

The present report is an analysis of 154 consecutive cases of acute obstruction of the small intestine treated at the Michael Reese Hospital from 1945 through 1950. The Michael Reese Hospital is a 700-bed general hospital, including a children's hospital. On the average, one new case of acute small bowel obstruction was treated every two weeks in this hospital during the period analyzed. In this

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* References 3 and 12.

† References 1 and 6.

study are included cases of obstruction of the small bowel from the ligament of Treitz to the ileocecal junction. Obstructions due to external hernia, paralytic ileus, and abdominal carcinomatosis are excluded.

MATERIALS AND METHODS

The data herein presented were gathered from the clinical and autopsy records of patients who were treated for acute obstruction of the small intestine during the six years 1945 through 1950.

The etiological classification of the cases is as follows:

1. Fibrous bands and adhesions
2. Inflammatory adhesions
2. Intussusceptions
4. Volvulus
5. Internal hernia
6. Primary tumor
7. Gallstone ileus
8. Congenital atresia and stenosis
9. Mesenteric embolus and thrombosis
10. Other causes

The heading "Obstructions Due to Fibrous Bands and Adhesions" includes all cases in which there was a mechanical obstruction due to occlusion of the lumen of the bowel by fibrous bands or by adhesions. Under "Inflammatory Adhesions" are considered those cases of mechanical obstruction which were caused by an acute or a subacute inflammatory process adjacent to or in the bowel wall itself. Most of the intussusceptions studied were of the usual type occurring in infants and were numerous in this series because of the relatively large size of the pediatric service at our hospital. Several cases of volvulus occurred. In these, torsion of the involved bowel was on the basis of either a malrotation of the intestine or an adhesive band. Herniations into recesses of the abdominal cavity, through congenital or operative defects in the mesentery and under adhesions, are considered in the group of internal hernia. The primary tumor group includes two cases of obstruction due to sarcoma of the ileum. Congenital atresia and stenosis comprise a relatively large number of the cases in this series for the same reason as does the intussusception group. Mesenteric vascular occlusions include those cases in which the diagnosis was established on definite clinical evidence or autopsy findings. None of the cases of mesenteric vascular occlusions was operated upon because of the moribund condition of the patients at the time they were seen. A case of mechanical obstruction due to stricture at the site of a previous small bowel resection and anastomosis and several cases of unknown etiology are included under the heading of 'Other Causes."

The condition of the bowel wall was evaluated in each case, whenever possible, (*a*) by the description of the surgeon at the time of operation, (*b*) by the autopsy findings in fatal cases, or (*c*) by inference in those cases which recovered without surgery. It was also found convenient to classify the condition of the bowel wall under the following categories:

1. Satisfactory—no gross evidence of damage to the bowel wall
2. Discolored—discoloration of the bowel wall with return to normal color after release of the obstructing mechanism
3. Gangrenous—necrosis of the bowel wall

Other factors of interest in this study were tabulated, i. e., age incidence and duration of symptoms before surgery.

DATA

Mechanism of Obstruction.—Of the 154 cases of obstructions reviewed, 62 were ascribed to fibrous bands and adhesions, 6 to inflammatory adhesions, 48 to intussusceptions, 6 to volvulus, 6 to internal hernia, 2 to primary tumor, 5 to gallstone ileus, 9 to congenital atresia and stenosis, 3 to mesenteric vascular occlusions, and 7 to other causes.

Age Incidence.—The age incidence for each type of obstruction and the number of deaths within each group are shown in Table 2. The distribution of the various causes within the specified age groups is of interest. Of the 48 cases of intussusception, 5 occurred in the first 3 months of life, 26 occurred between the 3d and the

TABLE 2.—*Age Incidence*

	Year						
	0-1	1-10	11-20	21-40	41-60	61-90	Total
Fibrous adhesions or bands	4	1	1	22	22	12	62
Inflammatory adhesions	0	0	0	3	1	2	6
Intussusceptions	31	17	0	0	0	0	48
Volvulus	2	0	0	3	1	0	6
Internal hernia	0	0	0	0	4	2	6
Primary tumor	0	1	0	0	0	1	2
Gallstone ileus	0	0	0	0	0	5	5
Congenital atresia and stenosis	8	1	0	0	0	0	9
Mesenteric embolus and thrombosis	0	0	0	0	1	2	3
Other causes	0	0	0	3	3	1	7
Total	45	20	1	31	32	25	154
Deaths	8	1	0	0	4	6	19
Mortality rate	17.8%	5.0%	0	0	12.5%	24.0%	12.3%

TABLE 3.—*Relationship of Mortality to Duration of Symptoms Before Surgery*

	Hours Before Operation					
	1-12	13-24	25-48	49-72	73-96	96 and Over
Cases, no.	15	25	18	13	15	35
Deaths, no.	0	0	1	2	3	2
Mortality rate, %	0	0	5.5	15.4	20.0	5.7

12th month of life, and 17 occurred in patients over 1 year of age. The oldest patient in this group was a 9-year-old boy in whom a Meckel's diverticulum had initiated the intussusception. There was only one death in this group of cases. This patient was a premature infant who was admitted to the hospital in shock and was not operated upon. Autopsy disclosed generalized acute peritonitis and lymphoblastic leukemia. Eight of the nine congenital anomalies were found in newborn infants during the first few days of life. Thirty per cent of these congenital anomalies were present in premature infants, all of whom died. All five cases of gallstone ileus occurred in elderly women in the seventh and eighth decades of life, and one of these patients experienced two attacks of gallstone ileus within a period of two years.

Duration of Symptoms Before Surgery.—Table 3 shows the mortality rate as correlated with the duration of symptoms before surgery. It is interesting to note that there was not a single death among the 40 cases which were operated upon

within the first 24 hours of the onset of symptoms. Also of interest is the observation that 35 cases were operated upon four or more days after the onset of symptoms and that the over-all mortality for this latter group was only 5.7%. This is probably due to the fact that the patients who survived for four days without surgery were those in whom the pathological process was not of a serious nature.

Condition of the Bowel Wall.—Table 4 indicates the condition of the bowel in cases with and without operation. The condition of the bowel was assumed to be satisfactory in those cases in which the obstruction relented with conservative management. The condition of the bowel was not known in some fatal cases which did not come to surgery or necropsy.

It should be noted that 122 out of 154 cases in this series were operated upon to relieve the obstruction. Twelve cases of acute intestinal obstruction due to fibrous bands or adhesions and 1 case attributed to inflammatory adhesions were treated successfully without surgery. In these cases the diagnosis of intestinal obstruction was established on clinical and x-ray evidence. Of the seven cases of

TABLE 4.—*Relationship of Mortality to Mechanism of Obstruction*

Cause of Obstruction	Total Cases, No.	Cases Operated on, No.	Condition of Bowel			Deaths and Mortality Rates
			Satisfactory	Discolored	Gangrenous	
Fibrous bands and adhesions	62	50	43	16	3	3 (4.8%)
Inflammatory adhesions	6	5	1	5 (inflamed)	0	1 (16.6%)
Intussusceptions	48	41	24	21	3	1 (2.1%)
Volvulus	6	5	2	2	2	1 (16.6%)
Internal hernia	6	4	2	1	3	3 (50.0%)
Primary tumor	2	2	2	0	0	0
Gallstone ileus	5	5	3	2	0	0
Congenital atresia and stenosis	9	8	4	1	4	7 (77.7%)
Mesenteric embolus and thrombosis	3	0	0	0	3	3 (100%)
Other causes	7	2	6	1	0	0
Total	154	122	87	49	18	19 (12.3%)

intussusception which were not operated upon, one was of a premature infant who died in shock before surgery could be performed and in the remaining six the obstruction was reduced by barium enema. One case of volvulus was not operated upon. The patient was a premature infant in whom the diagnosis was made post mortem. Two patients in whom the diagnosis of internal hernia with infarction of the small intestine was made at autopsy were admitted to the hospital in shock and were not operated upon. One patient with congenital atresia of the jejunum was not operated upon and died because of failure in making the diagnosis. Five cases of acute intestinal obstruction under the heading of "Other Causes" were not operated upon because they were completely relieved on conservative treatment and the cause of the obstruction was not determined.

In Table 5 the condition of the bowel wall, in those cases in which it was known, is correlated with the average duration of symptoms and the mortality rate. As was to be expected, the mortality rate increased with the severity of damage to the bowel wall. In those cases with gangrenous bowel the average duration of the condition was 96 hours and the mortality rate in this group was 78.5%.

A correlation of the condition of the bowel wall with the signs and symptoms of intestinal obstruction is shown in Table 6. As can be seen, there is no certain

way of distinguishing a strangulating from a nonstrangulating obstruction from the clinical picture and laboratory findings alone. Many cases with a nonstrangulating type of obstruction had tenderness, rebound tenderness, abdominal wall rigidity, rapid pulse rate, and an elevated white blood cell count. On the other hand, numerous cases with a strangulating obstruction did not present these clinical signs. It can be stated that a white blood cell count over 15,000, a temperature over 101 F. (rectal), and a pulse rate over 110 usually indicate a strangulating obstruction. Absence of these findings, however, does not rule out a strangulation.

TABLE 5.—*Relationship of Mortality to Condition of Bowel*

Condition of Bowel Wall	Average Duration of Symptoms, Hr.	Cases, No.	Deaths, No.	Mortality Rate, %
Satisfactory	80	77	2	2.6
Discolored	65	45	5	11.1
Gangrenous	96	14	11	78.5

TABLE 6.—*Correlation of Signs and Symptoms with Condition of Bowel*

Signs and Symptoms on Admission to Hospital	Cases, %		
	Simple Obstruction	Early Strangulation (Discolored Bowel)	Gangrene
Temperature over 101 F. (rectal)	13	22	64
Pulse rate over 110	26	27	60
Tenderness			
Local	31	65	60
General	25	35	20
Distention	67	64	93
Abdominal mass	26	55	43
Rebound tenderness	5	18	14
Borborygmus	56	33	14
Rigidity of the abdominal wall	18	29	22
White cell count			
10-15,000	33	75	30
Over 15,000	5	25	50

Previous Laparotomy.—Of the 62 cases of obstruction due to adhesions and bands, 53 had undergone previous abdominal operation. Of the nine cases which did not have a previous laparotomy, seven were due to congenital bands, one to an old pelvic inflammatory process, and one to an old Meckel's diverticulitis. In those cases in which the acute obstruction was attributed to postoperative or postinflammatory adhesions, it was found that gynecological operations (26 cases) and appendectomies (15 cases) were the commonest predisposing factors. Obstructions also occurred with less frequency after gall bladder surgery, stomach surgery, and penetrating wounds of the abdomen. The period of time which elapsed from the previous laparotomy to the onset of intestinal obstruction varied widely, ranging from 5 days to 45 years. Seven cases occurred within two weeks after a previous operation, but most of the cases occurred several years after the laparotomy.

TABLE 7.—*Data on Fatal Cases*

Case No.	Obstructing Mechanism	Age	Previous Operation	Duration of Obstruction, Days	Condition of Bowel	Type of Operation	Cause of Death
1	Fibrous band	47 yr.	Cholecystectomy and appendectomy 4 yr. previously	4	Discolored	Lysis of adhesions	Bile peritonitis due to rupture of hepatic duct obstructed by stones; acute cholangitis (autopsy)
2	Fibrous band	44 yr.	Appendectomy 25 yr. previously and hysterectomy 5 days previously	11	Discolored	None	Acute peritonitis and cardiac decompensation; old rheumatic heart disease (autopsy)
3	Fibrous bands	80 yr.	Hysterectomy 22 yr. previously	7-9	Gangrenous	None	Acute peritonitis (autopsy)
4	Inflammatory adhesions	73 yr.	Colon resection 12 days previously	6	Discolored	Lysis of adhesions; suture of perforation	Acute peritonitis, pneumonia, and pulmonary edema; no leak from sutured bowel (autopsy)
5	Intussusception	2 mo.	None	1	Discolored	None	Acute peritonitis, atelectasis, and acute leukemia (autopsy)
6	Volvulus	38 hr.	None	1	Gangrenous	None	Acute peritonitis, aspiration pneumonia (autopsy)
7	Internal hernia	65 yr.	Unknown	12 hr.	Gangrenous	None	Acute peritonitis, shock (autopsy)
8	Internal hernia	47 yr.	Cholecystectomy and appendectomy 7 yr. previously; ileocolostomy for carcinoma of colon 4 days previously	9	Gangrenous	None	Acute peritonitis, shock (autopsy)
9	Obturator hernia	77 yr.	Unknown	2	Gangrenous	None	Acute peritonitis, shock (autopsy)
10	Congenital atresia	2 days	None	1	Gangrenous	None	Acute peritonitis, aspiration pneumonia (autopsy)
11	Congenital atresia	2 days	None	2	Gangrenous	Exploration	Acute peritonitis, spontaneous perforations of bowel (autopsy)
12	Congenital atresia	1 day	None	1	Discolored	Ileostomy	Aspiration pneumonia, fetal peritonitis (old) (autopsy)
13	Congenital atresia	4 days	None	4	Satisfactory	Enteroenterostomy	Acute peritonitis; leak from suture line (autopsy)
14	Congenital stenosis	2 mo.	Exploratomy laparotomy 2 mo. previously	2 mo.	Gangrenous	Resection	Acute peritonitis, liver abscesses; leak from suture line (autopsy)
15	Congenital stenosis	18 mo.	None	2	Satisfactory	Enteroenterostomy	Acute peritonitis, myocarditis, leak from suture line (autopsy)
16	Congenital stenosis	4 days	None	4	Gangrenous	Closure of perforation	Acute peritonitis, spontaneous perforation of bowel (autopsy)
17	Mesenteric embolus	48 yr.	Unknown	7	Gangrenous	None	Myocardial infarct, pneumonia (autopsy)
18	Mesenteric thrombosis	70 yr.	None	8	Gangrenous	None	Acute peritonitis, myocardial infarct (autopsy)
19	Mesenteric thrombosis	68 yr.	Unknown	10	Unknown	None	Myocardial infarct, shock (autopsy not done)

Tabulation of Fatal Cases.—The data on all cases which ended fatally are presented in Table 7. There was a total of 19 deaths in this series, and the cause of death was determined by autopsy in all cases except one, in which the clinical diagnosis was a mesenteric vascular occlusion. Eight of the 19 fatal cases were operated upon. Of the remaining 11 cases, 5 were seen in a terminal state precluding surgery; 5 deaths could be reasonably attributed to failure in reaching a correct diagnosis, and 1 case died of unrelated causes. If we exclude the cases which were moribund on admission, the corrected mortality rate would be 9.9%. No death occurred during the last year of this study (1950).

There were 88 cases of obstruction in adults, with 10 deaths, a mortality rate of 11.4%. There were no deaths in patients between the ages of 2 and 40 years. As would be expected, the highest mortality rates were seen in infants and elderly patients (Table 2). In most cases, death was associated with acute peritonitis resulting from a gangrenous loop of intestine. Other conditions which contributed to the fatal outcome of several cases were pneumonia and myocardial infarction.

Of the eight fatal cases which were operated upon, five died as a result of acute peritonitis associated with leakage from a suture line. One patient died of bile peritonitis due to erosion of stones through the left hepatic duct; one died of aspiration pneumonia, and one died of a massive infarction of the small intestine.

The obstructing mechanism which was associated with the highest mortality rate was the congenital anomaly group, which accounted for 7 of the 19 deaths. Since 30% of these were prematurely born infants, their physiological response to disease and tolerance to surgery were extremely poor. The three cases of mesenteric vascular occlusion occurred in patients who were in the hospital because of myocardial infarction, and their condition was such that they could not tolerate surgery.

COMMENT

Delay in accurate diagnosis is probably the greatest cause of failure in the therapy of intestinal obstruction.‡ The successful management of these cases depends on an accurate differentiation of (1) large bowel from small bowel obstruction, (2) mechanical obstruction from adynamic ileus, and (3) simple from strangulating obstruction.

During the past two decades Wangensteen [15] and others § have established criteria for selection of certain types of cases of small bowel obstruction amenable to a trial period of nonoperative decompression therapy. It has been estimated that from 35 to 40% of small bowel obstructions could be successfully treated by nonsurgical means if only one could select the proper cases with unfailing accuracy. However, strangulating lesions which are not diagnosed before surgery continue to appear at the operating table so frequently as to cause serious concern about the adequacy of our present criteria and diagnostic methods.

The presence of strangulation must be ruled out early if one is to treat any cases of obstruction conservatively. Therefore, with the adoption of a policy of exploration in nearly every case of small bowel obstruction, the early recognition of strangulation assumes less importance, except to emphasize the urgency for immediate exploration in such cases. Estimates of the incidence of strangulation

‡ References 5 and 16.

§ References 9 and 13.

in reported series of cases varies with the definition of strangulation, but generally the figures run around 30%. McKittrick and Sarris [10] found strangulation in 33% of 136 cases; Schlicke, Bargen, and Dixon,[13] in 26% of 166 cases, and Calahan, Kennedy, and Blain,[2] in 27% of 204 cases. In our series, out of 136 cases in which the condition of the bowel wall could be ascertained, evidence of strangulation was found in 43%. Strangulation was the direct cause or an important contributing factor in 16 of the 19 deaths in our series. This fact reemphasizes the statement of McKittrick and Sarris [10] that "strangulation is the most important single factor in determining the outcome of a case of acute small bowel obstruction."

Strangulation may lead to infarction of the bowel wall within a few hours. In strangulation the classic findings of peritoneal irritation, leucocytosis, fever, silent abdomen, and shock are often not seen until the later stages of the process. Furthermore, any of the above findings indicative of strangulation may also be found in simple obstructions.

It is generally agreed that the commonest causes of death in small bowel obstruction are peritonitis and fluid and electrolyte loss. Even with the extensive use of antibiotic agents, and good replacement therapy with all kinds of fluids, electrolytes, blood, plasma, etc., the mortality rate in this disease has not improved sufficiently in the last 10 years. If nonoperative treatment is selected for any patient suspected of having a simple, nonstrangulating obstruction, the condition of the patient must be reevaluated every eight hours. If definite improvement in the signs and symptoms is not manifest within the first 8 to 12 hours, surgical intervention is mandatory. The one exception to this rule would be those cases with obstruction occurring within two weeks of an abdominal operation. These obstructions are probably due to inflammatory adhesions, and therefore one can afford to be more conservative. An additional 24-hour period of observation is often advisable in these special cases unless other findings suggest strangulation.

Less controllable factors which contribute to the high mortality rate in acute intestinal obstruction are the age of the patient,‖ complicating diseases, and delay on the part of the patient in seeking medical attention.¶ Certain types of obstruction, such as massive infarctions of the small bowel and congenital atresias or stenosis of the small intestine in premature and newborn infants,[11] are responsible in large part for the present high mortality figures because of their occurrence in poor surgical risk patients. More than 50% of the deaths in our series are accounted for by the latter causes. Even in these formerly "hopeless" cases, progress is being made in reducing the mortality rate.

SUMMARY

A report and analysis of 154 consecutive cases of acute obstruction of the small intestine treated at the Michael Reese Hospital from 1945 through 1950 is presented.

The over-all mortality in this series is 12.3%, with a corrected mortality of 9.9%.

The importance of early accurate diagnosis and application of sound treatment in this disease is reemphasized.

The most important causes of death are peritonitis, fluid and electrolyte loss, and the infirmities of age (the newborn and the aged).

‖ References 4, 7, and 11.

¶ References 7 and 8.

Strangulation occurred in 43% of our cases and was the direct or contributing cause of death in 84% of our fatal cases.

The difficulty in distinguishing between simple and strangulating obstruction on the basis of our present clinical and laboratory methods is reemphasized. Strangulation of the bowel may be found even in the absence of the usual diagnostic clinical signs and symptoms.

Early surgical intervention in acute small bowel obstruction is mandatory, with very few exceptions.

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TECHNIQUE OF COMMON DUCT EXPLORATION

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IN THE SURGICAL therapy of chronic gall bladder disease with stones, the indications for common duct exploration are specific and clear cut. On this surgical service, the common duct is opened and explored at the time of cholecystectomy under the following circumstances: (1) concomitant obstructive jaundice at the time of operation; (2) one or more episodes of jaundice in the past history of the patient; (3) finding of a dilated common duct at the time of cholecystectomy; (4) presence of a dilated cystic duct with small calculi in the gall bladder, and (5) finding of enlargement of the head of the pancreas due to chronic pancreatitis.

In the conduct of the operation under the circumstances enumerated above, the diseased gall bladder with its contained calculi is removed, with careful individual ligation of the cystic vessels and duct under direct vision. It has been found important to excise the entire cystic duct with ligation close to the common duct in order to obviate the possibility of the later development of the cystic duct syndrome, a well-defined entity recently the basis of a report by Garlock and Hurwitt.

By the judicious use of abdominal pads and strategic placement of deep retractors, the right edge of the gastrohepatic ligament with its contained structures is brought into clear view. Then follows the technical maneuver of common duct exploration. Usually, guy sutures are placed at the right and left edges of its anterior surface and a vertical incision is made between them. With the aid of duct probes, Bakes' dilators, various-angled narrow stone forceps, and catheter irrigation, the entire extrahepatic duct system is then explored for stones. Experience has shown that a negative exploration or the finding and removal of one or more stones does not necessarily indicate that other calculi may not have been overlooked. This frequently repeated observation has led a number of surgeons in this country and, particularly, Mirizzi in South America to reintroduce operative cholangiography as a method of disclosing calculi in the duct system which may be overlooked or by-passed by the commonly employed methods of exploration.

The fact that the surgeon is able to pass a probe or small sound through the papilla of Vater without meeting obstruction does not exclude the possibility of an overlooked calculus. We have repeatedly disclosed calculi situated to one side of the main channel of the common duct in little lateral diverticular projections of the duct. It is not at all uncommon to find small calculi embedded in a lateral projection of the papilla of Vater without obstruction to the free passage of a probing instrument. Under such circumstances, exploration by the usual methods with the surgeon standing at the right side of the operating table will frequently yield nega-

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tive results. The subsequent development of colic, chills, fever, and jaundice quickly establishes the diagnosis of an overlooked stone, and another operation then becomes necessary.

I shall describe a method of exploring the common duct which is simple to carry out and which will practically obviate the possibility of overlooking a calculus in the common duct, especially in its distal component. I believe Kocher originally suggested the method, and I am sure it has been used by other surgeons. It deserves description and more general adoption by practicing surgeons.

After the common duct has been opened between guy sutures, the proximal duct system is thoroughly probed well into the lobes of the liver and flushed with irrigating fluid. In my experience, it is rather unusual to find solitary calculi in the proximal part of the duct system. The flow of bile carries these small calculi toward

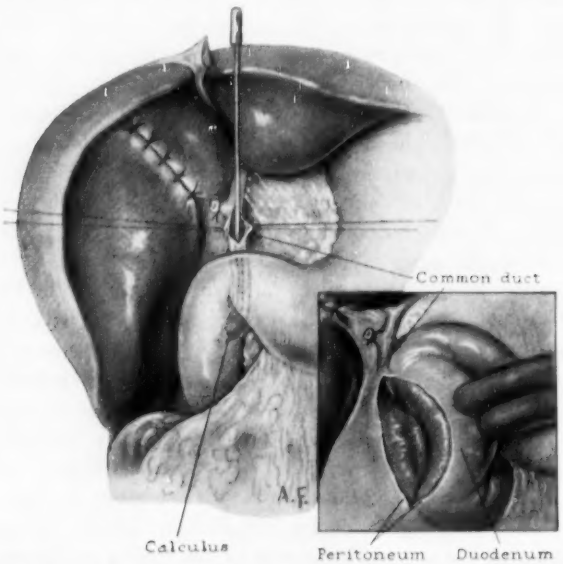

Fig. 1.—Exploration of the common duct with the aid of a small Bakes' dilator. Insert shows mobilization of the second portion of the duodenum, showing incision of the peritoneal attachment.

the distal portion of the common duct, and it is here that one finds most of these stones. The surgeon should now go over to the left side of the operating table and remove the pads and retractor from the duodenum and stomach. An incision is made in the lateral peritoneal attachment on the right side of the second portion of the duodenum which is bluntly pushed forward and to the left by the surgeon's left hand. The surgeon now holds the duodenum and contiguous pancreatic head between his left index and middle fingers behind and his left thumb in front. With the right hand he passes the smallest-sized Bakes' dilator which has been bent into a curved shape downward through the opening in the common duct toward the papilla. It is now possible to feel between the left hand fingers behind and the thumb in front every portion of the common duct and papilla. Small calculi become clearly delineated between the palpating fingers and may be extracted with ease with the aid of a

right-angled stone-grabbing clamp. Calculi wedged into lateral loculi of the main duct may thus be dislodged into the main channel and removed. With this method of duct exploration, transduodenal choledochotomy for a calculus impacted in the papilla is rarely necessary. It has been repeatedly demonstrated that an impacted calculus can be rather easily dislodged by the combined manipulations of the left hand fingers and a stone forceps in the duct controlled by the right hand. Occasionally one will encounter a large stone solidly wedged in and around the papilla in such a way as to render its removal in the intact state rather difficult. Under such circumstances, it is possible to break the stone into smaller fragments to permit its piecemeal removal. This is accomplished by fixing the stone between the fingers of the left hand and breaking it with the stone forceps held by the right hand. Thorough flushing distally will carry minute fragments into the duodenum.

Fig. 2.—The surgeon is at the left side of the table. The fingers of the left hand are placed behind the duodenum and contiguous head of pancreas. The left thumb is situated in front of these structures. With the instrument in the common duct, calculi are easily palpated and extracted.

It is important to emphasize two points in this technical maneuver. It is awkward and difficult to adequately palpate with the left hand the mobilized duodenum and pancreatic head if the surgeon remains at the right side of the table. The ease and thoroughness of this maneuver immediately becomes apparent when the surgeon carries it out from the left side of the patient. Secondly, the duct itself cannot be felt unless a probe or fine Bakes' dilator is passed downward at the same time. This instrument acts as a guide for the examining fingers of the left hand, and, because of its presence, one can more easily palpate calculi in any portion of the duct. The accompanying drawings depict the essential features of this method of common duct exploration. Its simplicity of execution and almost infallible accuracy go far to commend it, and I am therefore suggesting that it be given a thorough trial by other surgeons.

RETROGRADE INTUSSUSCEPTION OF A GASTROENTEROSTOMY STOMA

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RETROGRADE intussusception of a gastroenterostomy stoma is certainly one of the least common pathologic phenomena, however dramatic it may be, and a review of the literature shows few reported cases. As in all similar situations the number of cases reported in the literature is an index of its frequency but by no means an actual accounting of the true number of cases encountered in practice.

Intussusception of a gastroenterostomy stoma requires surgical intervention. Lawson and Whitener,[1] in reporting their case, reviewed the literature and showed that the first complication of this type following a gastroenterostomy was reported in 1917 by Steber,[2] and that 50 cases were reported in the literature by 1950. The first interest in this situation was demonstrated by the European authors; until 1933 only five case reports appeared in the American literature, and since that time only three additional cases appear in the American literature.*

Bettman and Baldwin's [2] review of 33 cases plus 13 additional cases reported up to 1950 was summarized by Lawson and Whitener [1] together with the report of their case. The initial symptoms in all cases have been epigastric pain followed by vomiting and later becoming either blood tinged or frankly bloody. In 17 of the 46 cases there was a palpable mass. In 11 cases, tenderness and rigidity of the upper abdomen were the only physical findings of significance. In 8 patients fullness and tenderness only were present, and in 10 patients neither a mass nor rigidity was noted. Dehydration and shock were noted in some of the patients, but the exact relationship to the degree of shock and dehydration cannot be correlated with the total duration of symptoms.

In those instances in which the time of operation could be correlated with total duration of symptoms, 19 patients were operated on in the first 48 hours, with 17 survivals; however, in those operated on after 48 hours, there were 7 deaths in a total of 13 cases. In those instances in which no surgery was performed, the patients all died. The gross surgical mortality was therefore 25%, but for those operated on within the first 48 hours the mortality was 10.5%.

It is interesting to note that in all the reported cases the diagnosis was made preoperatively in only three instances. In one case it was made by the physician, but in the remaining two the patients themselves made the diagnosis, inasmuch as they both had recurrence, up to the present the only two reported recurrences.[2]

The etiology of this situation is unknown, and the size of the stoma is not a factor, as was demonstrated by its occurrence in large as well as in small stomata. All reported cases acknowledge that the mechanism is that of reverse peristalsis, but

* References 1, 2, and 3.

the reason for the development of a reversal in the peristaltic wave at this point is not demonstrated. In 26 cases there was a posterior gastroenterostomy, and in 6 cases there was an anterior gastroenterostomy. In 10 cases enteroenterostomy had been done at the time of the gastroenterostomy.

These cases, then, represent the acute problem, but in addition to this, cases of chronic, intermittent intussusception have been reported by Butler,[4] Sibley,[5] and Cyrany.[6] In those cases reported the intussusception has been manifested by the onset of epigastric pain, nausea and vomiting, and spontaneous subsidence. The diagnosis has been made by roentgenographic studies which demonstrated a defect in the midportion of the stomach which could eventually be surrounded by barium as the stomach filled, leaving a large "island" defect in the gastric shadow which was then totally free of barium. One must wonder if this may not be one of the mechanisms in the so-called dumping syndrome.

The consideration of either acute or chronic intussusception of a gastroenterostomy stoma is necessary in the differential diagnosis of a patient who presents himself with either pain, nausea and vomiting, or hematemesis at any time in the period subsequent to the performance of a gastroenterostomy. The following case is illustrative of the problem.

REPORT OF A CASE

A 54-year-old man was admitted for exploration of the cervical cord for a possible herniated intervertebral disc. In 1948 the patient had a ruptured intervertebral disc removed, but there were residual disc or peridural adhesions. A review of his past history showed that in December, 1932, he had an excision of a duodenal ulcer and a duodenoplasty. In May, 1933, he had a posterior gastroenterostomy performed. Subsequent to this he had few symptoms referable to the gastrointestinal tract and specifically no hematemesis or melena. On Jan. 21, 1953, a cervical laminectomy was done, with transdural exploration of the cord and lysis of perineural adhesions.

The postoperative course was uneventful in the next 24 hours. On Jan. 22, the first postoperative day, the patient ate breakfast, but within an hour noted periumbilical pain, crampy at first and then becoming constant. At 10 o'clock he vomited about 300 cc. of bloody material in a projectile fashion. Following this he vomited about 100 cc. of bloody material every half hour. Shortly after the onset of the hematemesis he was seen by a medical consultant. Findings showed the history as above, blood pressure stable (110/70), color fair. Abdomen showed spasm with epigastric tenderness, and a poorly outlined mass was felt which had not been palpable on the preoperative physical examination. It was felt that in view of the past history of peptic ulcer disease, this was evidence of an acute exacerbation with hemorrhage, but the possibility of perforation was also considered. The patient was placed on gastric suction through a Levin tube, and blood and fluid replacement was instituted.

Despite sedation and blood replacement, the bleeding continued and the blood pressure began to fall slightly. In the next 10 hours the patient lost 2,400 cc. of blood or at least gastric drainage which was largely blood. He had been given 2,000 cc. of whole blood and 500 cc. of plasma.

In this period since bleeding became more vigorous he was also seen by the surgical consultant, and it was felt that the bleeding was not responding to conservative measures and that previous surgery would constitute technical difficulties which would add to the hazards of the procedure. In view of this it was felt that it would be wisest to explore the patient as promptly as possible, so that he would be able to withstand a tedious operation.

The patient was explored through a transverse, upper abdominal incision. There was a large volume of clear, straw-colored fluid, no evidence of perforation. There was a large mass in the upper abdomen, which could not be identified because of the adhesions and distortion resulting from the previous surgery. Only after further exploration was it possible to identify the mass as the result of an intussusception of the gastroenterostomy into the stomach. The intussusception could not be reduced by external pressure or traction. To facilitate handling of the mass, the duodenum was dissected free and then transected. The stomach was now more readily mobilized

and opened along the lesser curvature. At this point the intussusception could be seen, and by milking the intussuscepted loops a reduction was accomplished. There were 36 in. (91.4 cm.) of bowel involved in the intussusception, but after packing in warm saline sponges it appeared to be viable. The distal two-thirds of the stomach was resected; the old jejunal loop was used to make a new gastroenterostomy, and the patient was left then with a Polya-type gastrectomy. During the procedure blood was replaced as lost, and an additional 3,000 cc. of whole blood was given in addition to the 2,000 cc. given preoperatively. The patient made an uneventful recovery and was discharged on the 10th postoperative day. He has been seen periodically since then. There has been no recurrence, and he has had few symptoms referable to the gastrointestinal tract. The pathological diagnosis of the resected stomach showed only edema and bloody infiltration of all layers; there was no residual ulcer.

COMMENT

The literature has been reviewed, and it shows that, although the incidence of intussusception of a gastroenterostomy stoma is not high, the condition nevertheless does occur and must be borne in mind whenever a patient presents himself with pain, vomiting, and bleeding in the period after a gastroenterostomy has been performed. Those patients who are operated upon have a relatively good prognosis, whereas those not relieved surgically have all died. A case is presented which is typical of those found in the literature and serves to emphasize that this condition must be borne in mind when considering the course of treatment for a patient who has both the problem of severe bleeding and that of having a gastroenterostomy.

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REDUCTION OF PULMONARY RESERVE

1. Technique for Reducing Pulmonary Capacity to Fifteen per Cent, with Measurement of Right Heart Pressures and Arterial Blood Oxygen Saturation in Dogs at Rest and During Exercise

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THE CARDIORESPIRATORY readjustments after reductions of the lung area and after production of shunts in the lesser circulation have long been a problem of interest to one of us (W. E. A.).[1]

Reduction of lung parenchyma beyond 50% is difficult to accomplish by actual surgical removal of lung tissue. This is probably because of the ensuing sudden increase of tension in the pulmonary artery, due to the decrease in the vascular bed of the lung, and to circulatory disturbances due to shifting of the heart and great vessels.

Attempts have been made in this laboratory to eliminate effects due to mediastinal shift by methods directed at reducing the pleural dead space after removal of lung area. The studies of R. A. Rasmussen and W. E. Adams [11] and of F. J. Phillips and W. E. Adams [10] on the gradual surgical ablation of lung tissue plus bronchial stenosis had this purpose. The same goal was attempted when we tried to fill the post-resection space with plastic sponges.[3]

In order to evaluate possible overloading of the right heart following surgical reduction of the pulmonary arterial bed, careful study was made of the changes in the right ventricular pressures accompanying the progressive reduction of lung tissue. In all these studies the time given to the cardiorespiratory unit to recuperate from the previous loss of lung parenchyma was considered to be a significant factor.[2]

Our interest on the whole subject was increased when necessity arose to attempt to remove several arteriovenous fistulae in the right lung of a patient who seven years previously had undergone a left pneumonectomy for the same pathology. Since then we have been working on a series of studies involving the "in vivo trans-pulmonary oxygen dissociation curve" as a test of pulmonary function.* The object

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* References 6, 7, 8, and 9.

of these studies at the present time has been to measure the relative amount of shunting of blood past normal lung and of diffusion difficulties in patients with pulmonary disease.

In the present paper we wish to describe the method used for occluding a bronchus, a pulmonary artery, or both, in order to produce a shunt-like effect, a diffusion difficulty, or pulmonary hypertension. The principle involves use of a pneumatic "occlusion unit." It was originally used for blood flow studies with the electromagnetic flow meter of Kolin [5] to occlude the aorta and great vessels in order to calibrate the instrument for zero blood flow. This device consists of polyethylene sheeting, double-walled, sealed by flame and connected to a polyethylene tube of

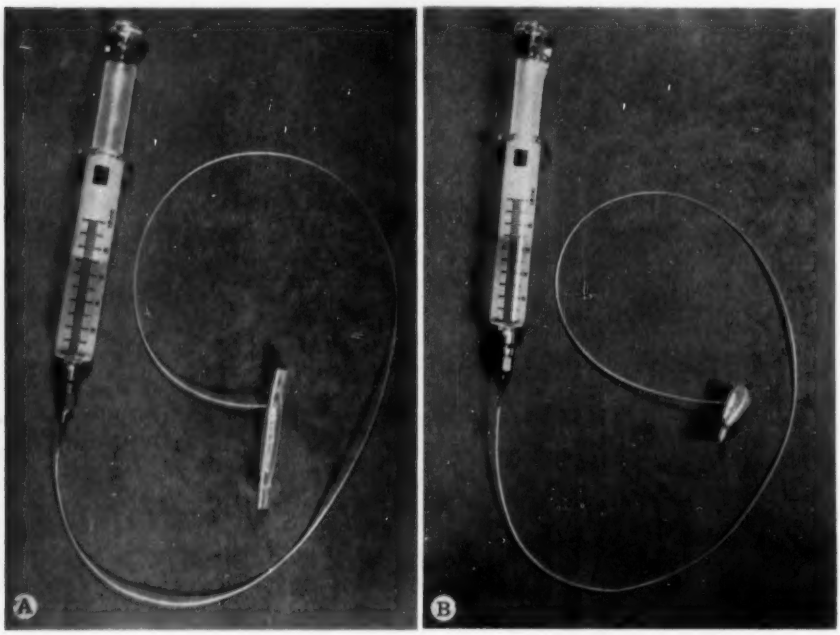

Fig. 1.—*A*, occlusion unit inflated. Note the distal flaps of the sac and the connecting tube entering the bag at one end. *B*, sac sutured by bringing the flaps together. Note the tightness of the closure.

0.25 mm. inner diameter. The size of the bag varies from 30 to 65 mm. in length and from 5 to 10 mm. in width, according to the size of the vessel to be occluded. The tube is 50 cm. long. The sac itself has at its ends two flaps which are used for sewing it around the vessel. The sac is insufflated by means of a 10 cc. syringe, using a 24 or 25 hypodermic needle inserted into the distal end of the polythene tube (Fig. 1*A* and *B*). The sac has the quality of being elastic, so that once the syringe is disconnected the bag empties itself promptly. The bag is tested for leakage by immersing it in water and injecting air at a pressure of 400 mm. H_2O. Before being used these units are sterilized by immersion in a 1:1,000 aqueous benzalkonium (Zephiran) chloride solution for 48 hours.

In our experiments we used dogs in which one of the lungs had been surgically removed 4 to 12 months previously. The pleural cavity containing the remaining lung was opened through the fifth interspace. In these operations both the anesthetist and the surgeon worked together to keep the remaining lung functioning at its maximal possible capacity; the former, by administering a high concentration of oxygen and by providing adequate ventilation, and the latter, by carrying out the surgery in spite of the almost completely inflated lung.

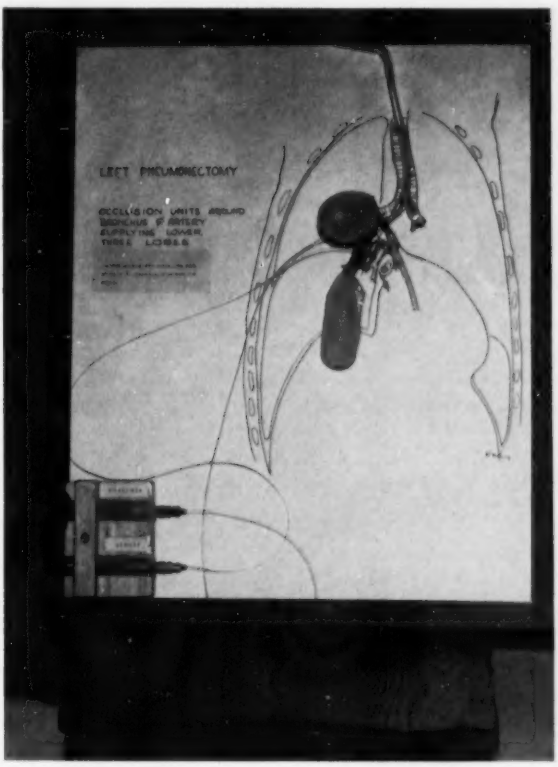

Fig. 2.—Schematic representation of what is done in vivo. The unit placed around the intermediary segment of the right bronchus prevents the inflation of the three lower lobes, represented here by the inferior bag.

The procedure involved in applying the occlusion units was as follows:

The intermediary segment of the pulmonary artery was carefully and gently mobilized over a length of 12 to 18 mm. Next the lower lobe bronchus on the left or the bronchus below the origin of the upper lobe on the right were similarly exposed. In both of these procedures, the peribronchial tissue, as well as the adventitia of the pulmonary artery, was left intact. When the vascular and bronchial structures were adequately freed, the proper size occlusion units were selected and were tested again for leakage. The polyethylene sac was first placed around the vessel, and the two flaps were brought together and sutured by three interrupted stitches. The vascular unit was then tested in situ in order to see how much air should be injected in order to stop the blood flow completely. After application, each bronchial unit was also tested, by

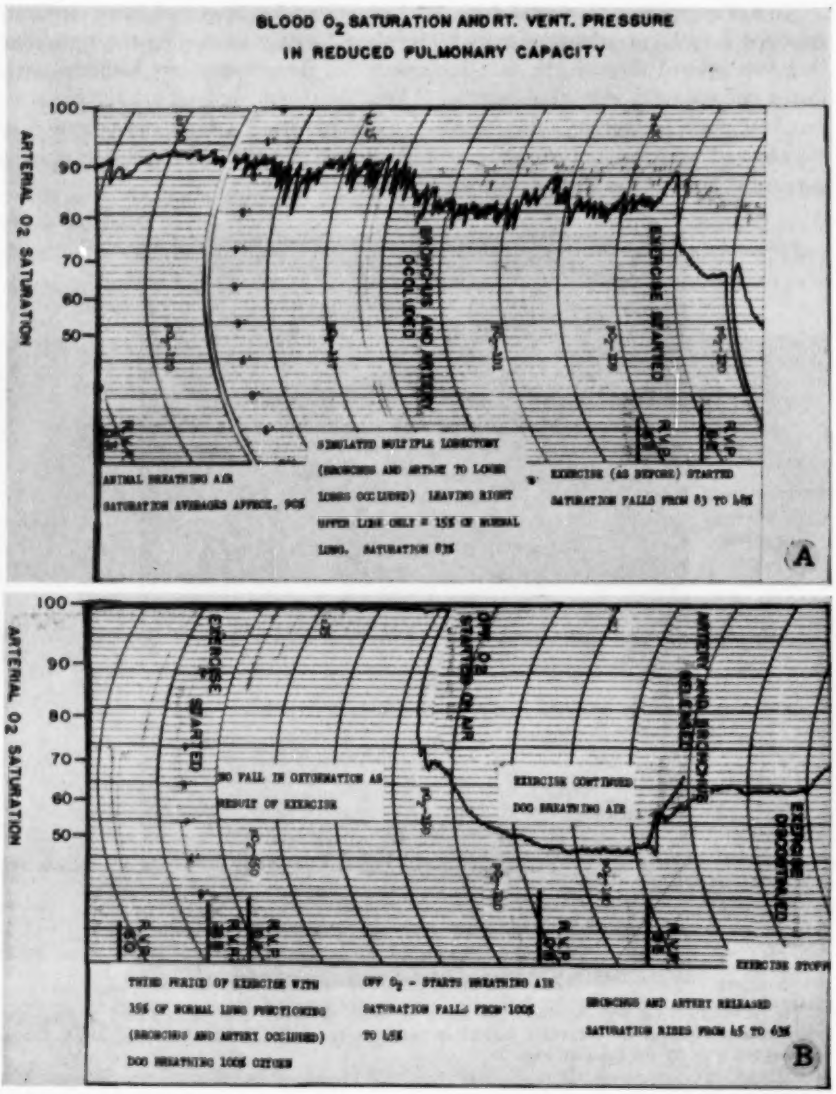

Fig. 3.—*A*, with the right upper lobe as the only lung tissue functioning, the arterial blood oxygen saturation keeps an average of 83% while the animal is under anesthesia and breathing air; the right ventricular pressure came up to 69 cm. H_2O. A sudden drop in the arterial oxygen saturation to 48% and a rise in the right ventricular pressure to 100 cm. H_2O occurred when the animal was exercised. *B*, with only the right upper lobe at work and the animal under induced exercise, the arterial blood oxygen saturation was brought up to 100% when breathing 100% oxygen; the right ventricular pressure came up to 94 cm. H_2O. Note also how the change to room air produced a sudden drop of the arterial blood oxygen saturation to about 40% and the right ventricular pressure rose to 108 cm. H_2O. The opening of the three lower lobes to function brought the saturation to 63% and the ventricular pressure to 96 cm. H_2O.

deflating the lung, inflating the unit, and administering a positive endotracheal pressure of 15 to 20 cm. of water. If no inflation of the corresponding lobe occurred, the test was considered successful. The fine polyethylene tubes connected to the inflatable cuffs were next brought out through the fourth interspace to the subcutaneous layer, where they were coiled up, tied, and left under the skin. The chest was closed in the usual way. In closing the chest, the lung was completely expanded and the pleural space obliterated. This was effected by means of a No. 18 intrapleural catheter, through which the air remaining was aspirated; the catheter was then removed. In the immediate postoperative period, fluoroscopy and chest x-rays were used to check the expansion of the lung. Figure 2 is a schematic representation of the procedures just described.

The following protocol illustrates a representative experiment.

Dog 737 had a left pneumonectomy performed Nov. 11, 1951. On March 18, 1952, occlusion units were placed around the right pulmonary artery and the right main bronchus in the manner previously described. The final experiment was carried out on March 25. The animal was given an anesthetic dose of veterinary pentobarbital (Nembutal) sodium intravenously and was then heparinized. Through the right external jugular vein a radiopaque catheter was introduced into the right ventricle under fluoroscopic control. The cuvette oximeter was connected to the femoral artery and vein in order to get a continuous fast flow of blood past the photocells; the trachea was intubated by means of a cuffed tube which was attached to the Rahn alveolar sampler. The polyethylene tubes were withdrawn from the subcutaneous nest through a small incision and their ends were connected with two 10 cc. syringes. Both the oxygen analyzer and the oximeter had been calibrated previously. The relation between alveolar pO_2 and arterial saturation was then determined with the animal breathing different O_2-N_2 mixtures. Then, by occluding both bronchial and arterial units, the area of lung available for diffusion was reduced to the right upper lobe alone (15% of the total normal), and right ventricular pressures and alveolar pO_2 oxygen saturation of the arterial blood were obtained. The next step was the production of an arteriovenous fistula by occluding the bronchus to the three lower right lobes, with 10% oxygen trapped in these lobes, leaving intact the arterial flow to that parenchyma. Again the changes in right ventricular pressures, alveolar pO_2, and oxygen saturation of the arterial blood were determined, the animal being given different O_2-N_2 mixtures.

The last step consisted in the induction of exercise by means of an electrical current through electrodes applied to the four extremities of the animal. Changes in right ventricular pressures, in alveolar pO_2, and in oxygen saturation of the arterial blood were again recorded, the animal breathing several O_2-N_2 mixtures and under the three following circumstances: (1) using the entire right lung, (2) having just the right upper lobe at function, and (3) having all the pulmonary arterial flow intact but the ventilation to the middle, lower, and accessory lobes suppressed.

A brief analysis of Figure 3 (*a* and *b*), representing special moments of this experiment, will illustrate better what was said above.

We believe that these units can be used in other zones of the body to stop any kind of flow temporarily, intermittently, constantly, or for as long periods of time as desirable. They do not show any untoward tissue reaction or any tendency to erode the structures. A fibrinous cover finally surrounds the unit but does not interfere with its function.

SUMMARY

A method has been described and illustrated for reducing the lung capacity in dogs to 15% of normal. This entails the use of a polyethylene occlusion unit.

By occluding the bronchus only, a marked arteriovenous fistula was created and the altered physiological effects were demonstrated.

Changes in pressures of the right heart concomitant with those of altered arterial blood oxygen saturation are presented.

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INTRA-ARTICULAR BONE-GRAFT RESORPTION IN TRANSARTICULAR BONE-GRAFT ARTHRODESIS

Experimental Studies

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LEXER,[1] in 1906, introduced the transarticular bone-graft arthrodesis in cases of postparalytic foot drop. This method was used extensively for many other joints and other diseases. But soon one saw the disappearance of the bone graft in the joint space. In most cases no bony arthrodesis occurred. This phenomenon gave rise to two explanations. Lexer and his pupils * were of the opinion that mainly mechanical forces were responsible for a creeping fracture of the bone graft. Bier and his school † thought that the chemical nature of the synovial fluid caused a dissolution of the bone graft in the joint space.

Up to now these two theories are discussed but are still open to question. All arguments for and against these two theories have been based merely on clinical experiences and roentgenological observations. One wonders why no clear-cut animal experiments have been done to clarify these two conflicting theories. Fu-Yin Pan,[16] for example, who worked in Bier's clinic, did some experiments on dogs. He drove small bone splinters into the articular cartilage of the condyle of the femur in such a manner that they had no contact with the other articulating bone and capsule. He himself concedes that the disappearance of the part of the bone splinters within the joint space was not comparable to the phenomenon observed in the transarticular bone grafting.

An answer to these two opposite theories can be reached only by animal experiments which simulate the characteristic operative conditions seen in human beings. It must be a question either of a change in the chemical action of the synovial fluid or in the mechanical conditions of the joint operated upon. Since one cannot change the selective chemical agents in the synovial fluid, it would be more logical to study the mechanical or functional conditions of a joint.

If one presumes that the disappearance of the bone graft within the joint space takes place by mechanical forces as a creeping fracture, this phenomenon cannot occur if movements of the joint are perfectly controlled by an exact experimental technique. On the other hand, if one presumes that this phenomenon is caused by the chemical action of the synovial fluid, this must occur even when all mechanical forces are entirely eliminated. If the experimenter intends to prevent the occurrence of all mechanical forces from the transarticular bone-graft he has to prevent first all active and secondly all passive movements of that particular joint.

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* References 1 to 10.

† References 11 to 16.

EXPERIMENTAL PROCEDURE AND FINDINGS

The following experiments were performed on healthy adult dogs.

Experiment A.—In order to paralyze all muscles which move the right knee joint a hemilaminectomy was performed and the right roots of the motor nerves from L 2 to S 3 were cut. After a lapse of 10 months to allow for the shrinkage of muscles and capsule the following operation was done:

High amputation of the right leg was done in such a way that a tibial stump of about 2 cm. remained. From the amputated portion a cortical bone graft without periosteum was removed. Through the marrow cavity of the stump a 5 mm. (diameter) hole was drilled axially to the marrow cavity of the femur through the knee joint. The drill was allowed to remain, to be replaced later by the ade-

Fig. 1 (Experiment A).—*A*, roentgenogram taken immediately after operation. Between the three Kirschner wires the transarticular bone graft is seen. *B*, roentgenogram of the specimen in two positions, 12 months after operation, with the wires removed. Note the bony arthrodesis of the anterior half of the knee joint.

quately prepared bone graft. Three strong Kirschner wires were driven in through the three corners of the cortical layer of the tibial stump in such a way that they ran parallel to the drill into the femur. By this means the stump was well fixed to the femur. The drill was now removed and the bone graft took its position.

By this technique the following experimental conditions were achieved:

1. No active joint movement is present as a result of the paralysis of the muscles.

2. The high amputation of the leg does not give rise to a pendulum-like movement, thus eliminating a great part of the passive forces. The impossibility of resting or pressing the limb on the ground and bending of the knee joint also checks passive forces. The last and only thinkable passive movements to the bone graft are prevented by the three Kirschner wires (Fig. 1 *A*).

It is absolutely certain that by this method all conceivable active and passive movements are eliminated, including even micromovements that may still occur in the best plaster-of-Paris technique. The greatest part of the joint is intact, thereby allowing a sufficient supply of synovial fluid to act on the bone graft.

A follow-up roentgen control revealed a continuous healing of the bone graft without signs of resorption in the joint space. A year later the anterior part of the joint was observed to be filled with spongy bone, thereby demonstrating that bony arthrodesis had occurred (Fig. 1 *B*).

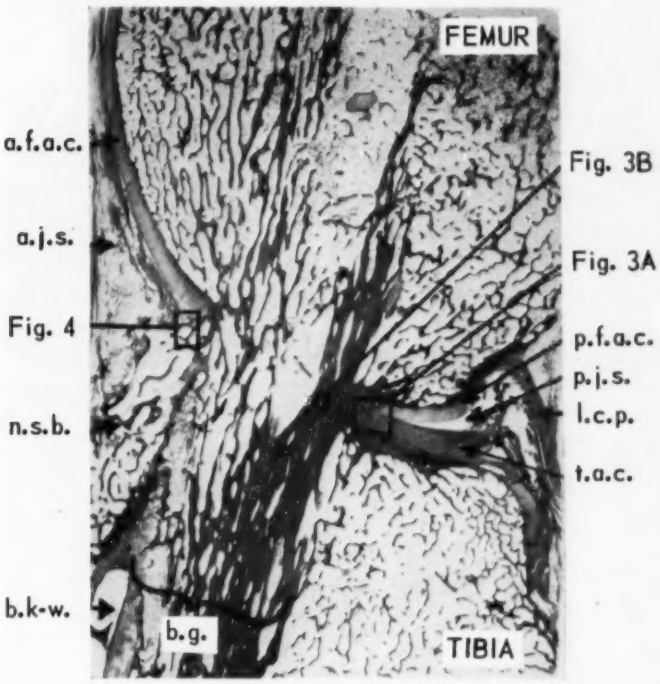

Fig. 2 (Experiment A).—Photomicrograph of the histological section, low magnification. *a.f.a.c.*, anterior femoral articular cartilage; *a.j.s.*, anterior joint space; *n.s.b.*, new spongy bone; *b.K-w.*, bed of Kirschner wire; *p.f.a.c.*, posterior femoral articular cartilage; *p.j.s.*, posterior joint space; *l.c.p.*, ligamentum cruciatum posterius; *t.a.c.*, tibial articular cartilage; *b.g.*, ligamentum cruciatum posterius; *t.a.c.*, tibial articular cartilage; *b.g.*, bone graft. Framed fields in higher magnification are shown in Figures 3 and 4.

The histological examination revealed that the bone graft had been replaced by living bony tissue. No signs of chemical synovial influence, such as necrosis, decalcification, etc., were demonstrable (Figs. 2, 3, and 4).

The above-mentioned experiment shows that the synovial fluid has no action on a transarticular bone graft when all active and passive movements are eliminated.

One can theoretically raise two objections to this experimental conclusion. By severing the right spinal roots, on the one hand, the power of bone formation may be increased and, on the other hand, the bone-destroying chemical factors of the

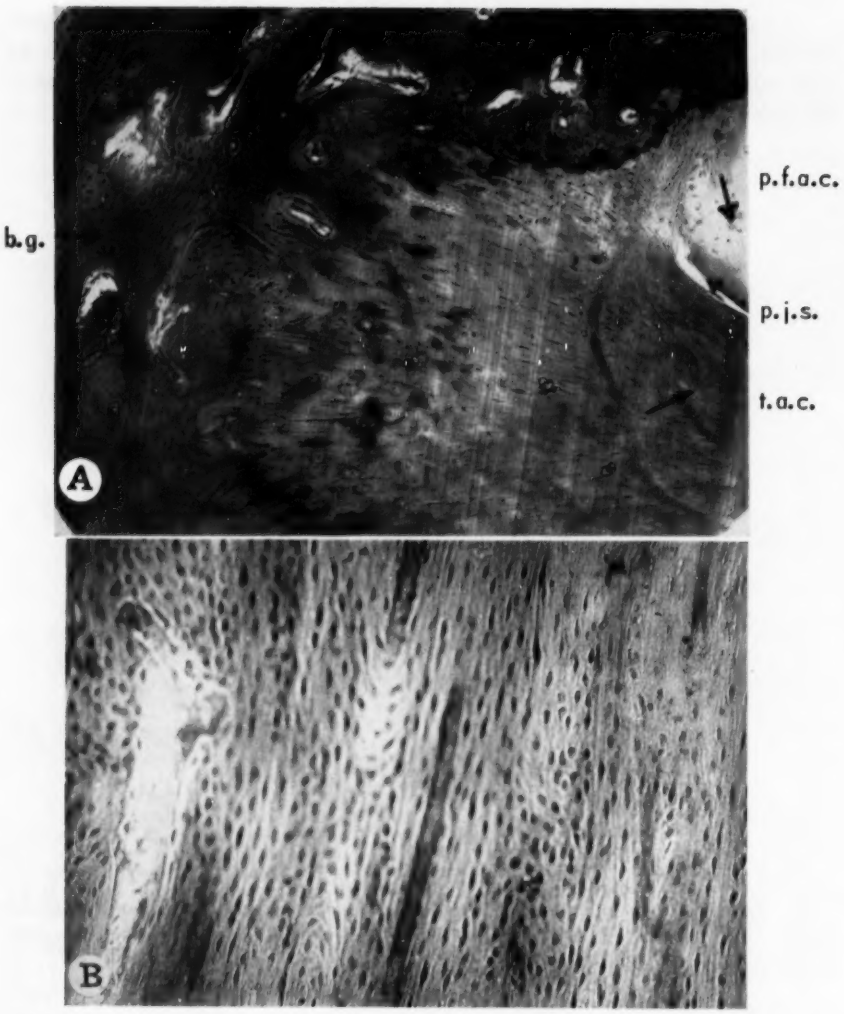

Fig. 3 (Experiment A).—*A*, details of Figure 2 in higher magnification: *b.g.*, bone graft; *p.f.a.c.*, posterior femoral articular cartilage; *t.a.c.*, tibial articular cartilage. *B*, photomicrograph of center of the bone graft at the level of the joint space (highest magnification). Note living bone with well-stained nuclei on the osteocytes.

synovial fluid may be decreased. Despite the fact that there is no demonstrable basis for these two objections adequate control experiments were carried out in order to answer these two doubts (Experiments B, C, and D).

Experiment B.—As in Experiment A the right spinal roots were severed and the tibial stump was fixed, but the drill hole was left without a bone graft. If one supposes that the severing of the spinal roots might increase the bone formation and decrease the hypothetical bone-destroying chemical factors of the synovial fluid,

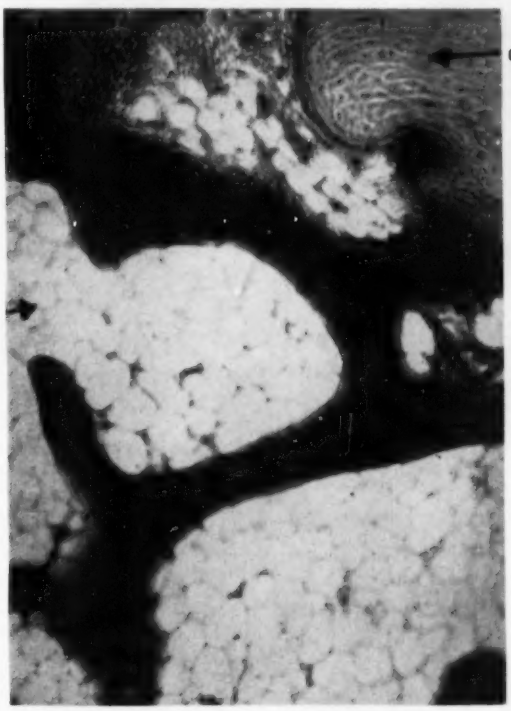

Fig. 4 (Experiment A).—New-formed spongy bone in the anterior joint space (high magnification); *a.j.s.*, anterior joint space; *a.f.a.c.*, anterior femoral articular cartilage; *n.s.b.*, new spongy bone.

it might be assumed that the bony arthrodesis could occur even in this experimental procedure (Fig. 5 *A*).

Follow-up roentgen controls and the anatomical specimen examined macroscopically and microscopically after 10 months showed that bony arthrodesis did not take place (Fig. 5 *B*).

Therefore this experiment proves that the severing of the spinal roots does not play any part in the problems discussed in this paper and that the above-suggested objections to Experiment A have no scientific support. This is further proved by Experiment C.

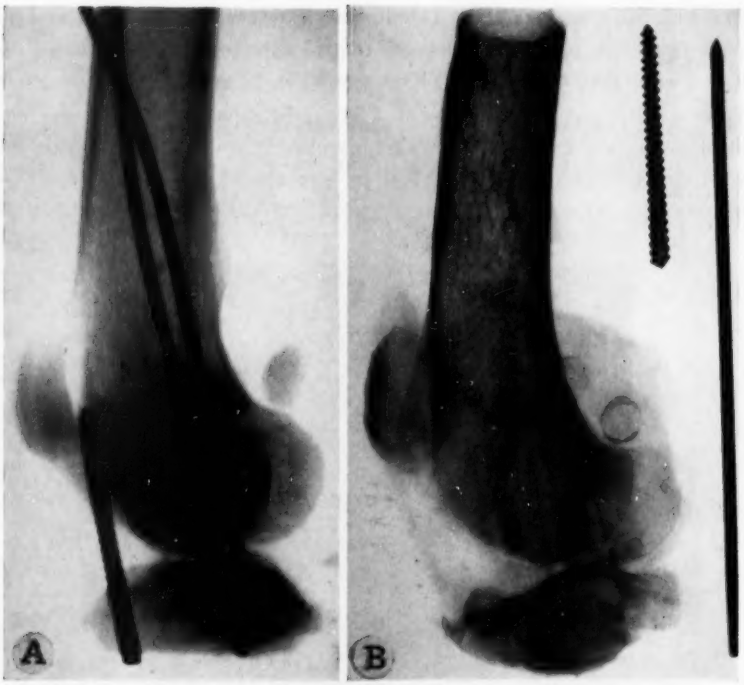

Fig. 5 (Experiment B).—*A*, roentgenogram taken immediately after operation. *B*, roentgenogram, 10 months after operation, showing no bony arthrodesis. For discussion see text.

Fig. 6 (Experiment C).—*A*, roentgenogram taken immediately after operation. The bone graft can be seen between the pin and the screw. *B*, roentgenogram taken three months after operation with specimen in another position.

Experiment C.—In this experiment the spinal roots were not severed. A great deal of care was taken to prevent all active and passive movements by the following arrangement: The very short tibial stump was fixed to the femur by means of a

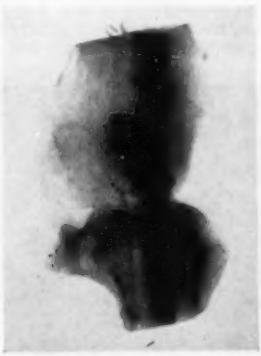

Fig. 7 (Experiment C).—Specimen taken 10 months after operation, showing no bone graft resorption.

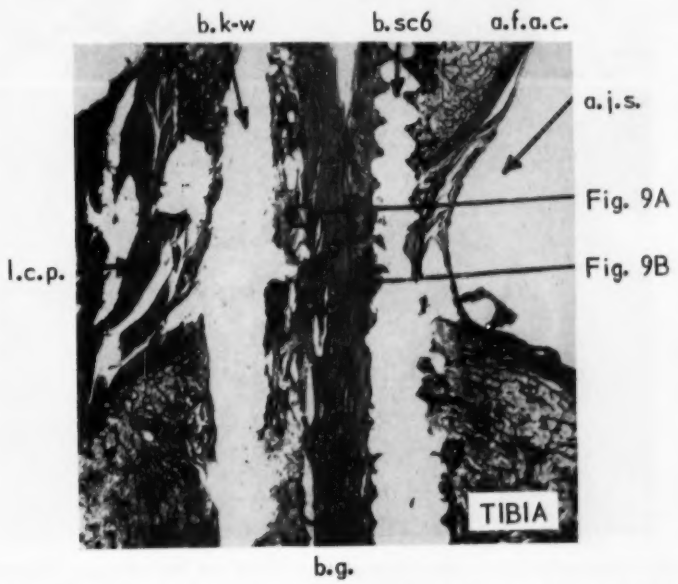

Fig. 8 (Experiment C).—Synoptical photomicrograph: *b.scr.*, bed of the screw; *a.f.a.c.*, anterior femoral articular cartilage; *a.j.s.*, anterior joint space; *b.g.*, bone graft; *l.c.p.*, ligamentum cruciatum posterius; *b.K-w.*, bed of Kirschner wire.

screw, which is more effective than nailing with Kirschner wires (Fig. 6*A*). In addition, the insertions of the flexor muscles were resected so that they had no contact with the tibial stump. The bone graft was then driven in, as in Experiment

A. Ten months later the roentgenological and histological results were exactly the same as in Experiment A: continuous healing of the bone graft without signs of resorption in the joint space (Figs. 6 *B*, 7, 8, and 9).

Experiment D.—This experiment gave the final conclusions. The technical procedure was as follows: Spinal roots were not severed; a longer tibial stump was

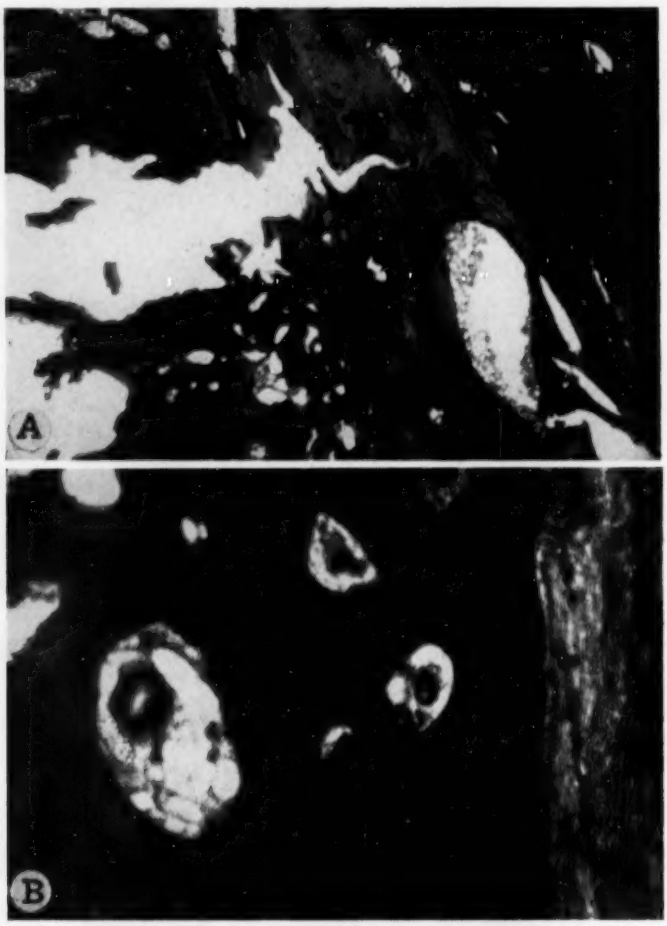

Fig. 9 (Experiment C).—*A*, photomicrograph of border of the bone graft (high magnification) at the level of the joint space (left). *B*, photomicrograph of anterior border of the bone graft (highest magnification) at the level of the joint space. The foreign body membrane of the bed of the screw can be seen in the right side of the picture.

allowed to remain in order to give free action to the knee flexor muscles. The fixation of the stump to the femur was not stable and was only done by means of two Kirschner wires. The bone graft was inserted as in Experiment A. After a period

of 10 months it was found that not only the bone graft but also the posterior steel wire had broken within the joint space and that the anterior Kirschner wire had disappeared spontaneously as had the distal part of the posterior broken wire. These were certain signs of instability and permanent joint movements. No bony arthrodesis occurred and the knee joint was movable to a certain degree (Fig. 10).

It is impossible for the synovial fluid to have caused a chemical dissolution of the steel wire. The only obvious explanation for the giving way of the steel wire in the joint space is that it was merely the result of continuous mechanical forces. No other explanation is therefore necessary for the fracture of the bone graft that was adjacent to the wire.

Fig. 10 (Experiment D).—Roentgenogram, 10 months after operation. Note the broken bone graft and posterior wire (anterior wire has disappeared spontaneously) due to permanent mechanical forces. For discussion see text.

SUMMARY

Evidence is presented that, on one hand, the synovial fluid acting alone in those experiments in which there were no movements whatsoever had no influence on the bone graft and that, on the other hand, in experiments with real joint movements the mechanical forces made the wire and the bone graft give way. This definitely seems to prove that the resorption of the intra-articular bone graft in transarticular bone-graft arthrodesis is due not to chemical but to mechanical factors.

Since an absolute immobilization of a bone-grafted joint in human beings cannot be guaranteed, the experimental findings in this paper cannot be directly applied to the clinical problem of transarticular bone-graft arthrodesis in operative surgery.

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RESIDUAL CHOLEDOCHAL STONES

Etiology and Complications in One Hundred Ten Cases

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A. JAMES McALLISTER, M.D.
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UNFORTUNATELY, not all operations on the biliary system are successful. When the surgeon fails to remove all offending intraductal calculi, the "residual" stones often provoke undesirable complications. The frequency with which secondary operations are employed is forceful testimony to such failures. We, too, have been embarrassed by this particular problem. Occasionally our primary operation has failed to relieve the intraductal obstruction, and the patient continued to suffer from the stasis of bile.

How frequently do calculi remain in the common bile duct after gall-bladder surgery? Does the clinical course after operation furnish reliable evidence of the presence of residual choledochal stones? Why are the elusive calculi missed at the primary operation? Can the frequency of residual biliary calculi be reduced? What treatment should be given to patients with these residual stones?

With the cooperation of the radiology departments in 11 hospitals in our area, we have conducted a study with the purpose of obtaining factual information in answer to these questions.

HOW FREQUENTLY DO CALCULI REMAIN IN THE COMMON BILE DUCT AFTER GALL-BLADDER SURGERY?

Postoperative cholangiography affords an excellent method for determining the presence of residual stones within the larger bile ducts. All patients, 550 in number, who had drainage tubes placed in gall bladders, cystic ducts, or common bile ducts were so studied. On the 7th to 10th postoperative days these drainage tubes were injected with a suitable contrast medium (35%, iodopyracet [Diodrast *]), and the resulting roentgenogram clearly defined the number, size, and position of the offending calculi. The diagnosis of "overlooked stones" was based therefore on positive roentgenological evidence and not on the mere interpretation of clinical syndromes. Errors in roentgenological interpretation were less than 0.5%, and no annoying complications developed as a result of such diagnostic studies.

Analysis of Table 1 demonstrates that of the 550 patients having stones removed from some segment of the extraheptic biliary system, during the primary operation,

From the Departments of Surgery, University of Utah School of Medicine, and Dr. W. H. Groves Latter-Day Saints Memorial Hospital.

* Solution Diodrast, 35% W/V, manufactured by Winthrop-Stearns, Inc., New York 18.

that 110 cases (20%) still harbored elusive intraductal calculi. It was interesting to note that in the bad-risk group, due to progressive jaundice, acute cholecystitis, neoplasm, age, or associated degenerative diseases, which were treated by cholecystostomy (25 cases) or by cholecystostomy and choledochotomy (35 cases), in which no serious attempt was made to remove all intraductal calculi, only 15% still carried residual stones, while in the group (75 cases) requiring choledochotomy for known stones (as in cases with reoperation), the incidence of "overlooked calculi" was 21%.

This survey comprises the work done in several small rural hospitals, in charitable institutions, and in teaching centers by the house officers, junior staff members, occasional operators, and experienced surgeons. It is an accurate picture of the results obtained in and around Salt Lake City. Farris, of Los Angeles, made a similar study by employing postoperative cholangiography and found that 22% still carried intraductal stones following primary choledocholithotomies. We are convinced that postoperative cholangiographic studies provide the most accurate method for determining the effectiveness of choledochal explorations. At least 45% of

TABLE 1.—*Residual Intraductal Stones*

Primary Operation	Cases, No.	Cases with Residual Stones	
		No.	%
Cholecystostomy (alone)	25	5	20
Cholecystostomy and choledochotomy	35	4	11
Cholecystectomy (tube in cystic duct)	15	2	13
Cholecystectomy and choledochotomy	400	83	20
Choledochotomy (alone)	75	16	21
Total	550	110	20

the patients in this series had insufficient postoperative clinical symptoms to warrant the diagnosis of "choledochal stones" yet their presence was confirmed by cholangiography.

DOES THE CLINICAL COURSE AFTER OPERATION FURNISH RELIABLE EVIDENCE CONCERNING THE PRESENCE OR ABSENCE OF CHOLEDOCHAL STONES?

It is generally believed that if a patient has an uneventful convalscence no complications, such as residual intraductal stones, could possibly exist. When the surgeons who had performed the primary operations on the patients in this series were informed of the presence of "overlooked" stones, nearly all of them countered with the reply, "Why, my patients had no 'missed calculi,' because they experienced such uneventful recoveries."

To explore this factor, a careful study was made of the hospital records of every patient included in this series. Moreover, 87 of the 110 patients were reexamined by us or by the original operators, and their progress after leaving the hospital was ascertained. In order to obtain uniform information, a questionnaire was filled out, the summary of which is presented in Table 2. It is not surprising that the early clinical course, immediately following the primary operation, provided little evidence as to the completeness of the initial exploration. Indigestion, pain, jaundice, and persistent fistulas may all be absent and yet the large bile duct still harbor residual stones. This has been demonstrated by findings at routine necropsies, in

which choledocholithiasis has been present without provoking signs or symptoms suggesting biliary disease. It must be remembered that many patients carry intraductal stones for many months or years before they produce sufficient symptoms to warrant surgical therapy. It is evident, then, that the accuracy of biliary explorations cannot be assessed by the manifestation of postoperative symptoms.

WHY ARE THE ELUSIVE CALCULI MISSED AT THE PRIMARY OPERATION?

Inasmuch as this survey represented the work of 26 different surgeons, of varied experiences and capabilities, it was hoped that study of the hospital records might shed some light on various factors and conditions which contributed to the incomplete removal of the gallstones.

Ductal Abnormalities.—Unfamilarity with the anatomic patterns of the larger bile ducts and failure to appreciate or detect the presence of ductal aberrations

TABLE 2.—*Clinical Course of Patients with Residual Choledochal Stones*

	Patients, %
Digestive Complaints	
Bloating or fullness after eating	52
Annoying flatulence	50
Intolerance to fats, condiments, etc.	53
Free from all distress	19
Pain complex	
Epigastric distress but no medication	4
Pain requiring mild analgesics	30
Pain requiring morphine, Demerol, etc.	47
No distress	19
Jaundice	
Mild jaundice	12
Deep jaundice	9
Secondary operations	
Reoperation at primary admission	13
Reoperation at a later date	61
Reoperation needed but refused	7
Symptom-free	19

seemed to characterize the work of the occasional operator. They were able to remove the gall bladders but could not cope with many of the unusual problems referrable to the bile ducts. It is estimated that fully 18 to 20% of patients present aberrations in the anatomical conformation of the extrahepatic biliary system. Failure to appreciate such situations may lead to serious consequences, as demonstrated by the following cases:

On one occasion the surgeon removed the gall bladder but was unable to find the common bile duct. A second laparotomy revealed the choledochus lying in a transverse plane within the abdomen, rather than in its usual position (Fig. 1). For this reason five stones were overlooked at the primary operation.

In another instance, a gall bladder situated in the lesser omental cavity was missed by two inexperienced surgeons, and it required a third operation before the elusive gall bladder was finally removed.

Figure 2 illustrates a case in which the cystic duct passed posterior to the common hepatic bile duct and then coursed down the left margin of this duct before the two fused to form the choledochus. This abnormality was not detected until a persistent biliary fistula necessitated another laparotomy, at which time both the aberrant cystic duct and the choledochal stones were removed.

Fig. 1.—The larger bile ducts lie in transverse plane, with residual stones blocking the ampullary outlet.

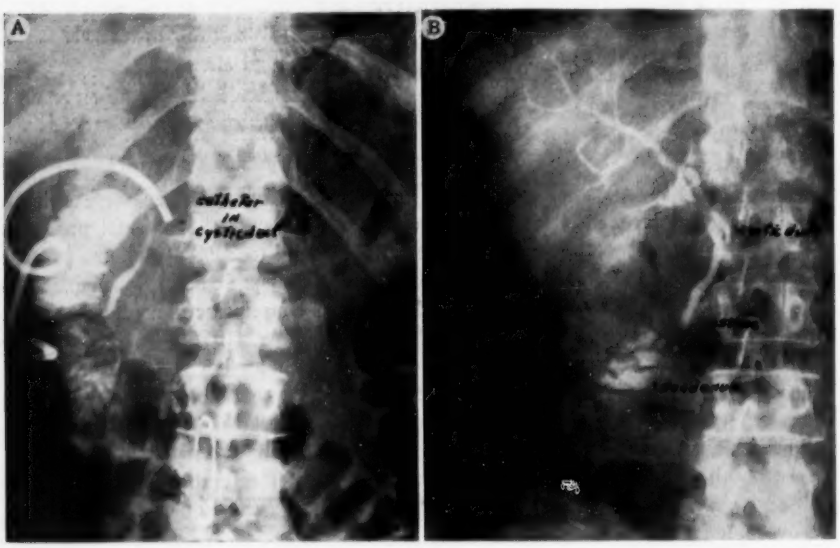

Fig. 2.—*A*, operative cholangiogram demonstrating the cystic duct passing behind and to the left of the common hepatic duct. The choledochus was not dilated or thickened, and no stones were palpable, yet the cholangiogram outlines a small calculus obstructing the ampulla of Vater. *B*, postoperative cholangiogram on the same patient six days later. The catheter is in the stump of the aberrant cystic duct. Note that the ampulla of Vater is now patent.

The patient shown in shown in Figure 3 developed a persistent biliary fistula after a cholecystectomy for a calculous cholecystitis. An increasing jaundice required a corrective laparotomy, at which time the common bile duct and the common hepatic duct were both found to contain large stones, and a second gall bladder filled with stones was also removed.

Hemorrhage.—Hemorrhage apparently plagued the occasional operators. In five cases it was necessary to stop the operation because of troublesome bleeding, even though the common ducts were known to harbor stones. Lahey [1] pointed out that undue traction on the gall bladder places excessive tension on the inelastic cystic artery, often avulsing it from the parent hepatic vessels and thus giving rise

Fig. 3.—Postoperative cholangiogram obtained by injecting iodopyracet into a fistulous tract remaining three months after cholecystectomy and choledocholithotomy. A second gall bladder, containing stones and calculi in all the larger bile ducts, was demonstrated.

to alarming and unexpected hemorrhages. Flint [2] emphasized the unusual anomalies which the cystic and hepatic arteries may present. If these are not recognized, a sudden gushing hemorrhage may provoke a serious problem.

Failure to Explore the Common Duct.—This was a common cause of residual stones. It would appear that many operators are not familar with the indications for such exploration. They may be able to recite the conditions which require investigation of the ducts, but they are unable to translate this didactic information into effective action in coping with the conditions found at the operating table. They fail to interpret certain clinical signs correctly because they do not understand thoroughly the limitations and shortcomings of these signs. Unless the ducts are greatly dilated or contain palpable stones, and unless the patient is jaundiced, they make no attempt to determine the existence of intraductal obstructions.

ARE THE CRITERIA FOR DUCTAL EXPLORATIONS RELIABLE?

It is standard teaching that dilatation of the bile ducts, the presence of a palpable stone, and the history of or the existence of jaundice are cardinal signs making exploration of the ducts mandatory. How reliable are these criteria? How many ducts harbor calculi without exhibiting these diagnostic signs?

Dilatation.—In order to detect any changes in the size of the common bile duct, one must have an accurate understanding of the norm. We have made actual micrometric measurements, at the operation and at necropsy, on 225 patients, none of whom had diseases of the biliary system. In 22% of the cases, the common bile duct measured 4.0 mm. or less in diameter; in 52%, the average was 5.0 mm., and in 26%, the ducts were 7.5 to 10.0 mm. or larger. It is obvious that at least 48% of these patients had common ducts larger or smaller than those described as normal in anatomy texts. This indicates that size affords a poor index as to the need for ductal exploration. Experience teaches that many of the dilated bile ducts do not contain stones, while many of the smaller ones are filled with gravel or biliary sand. If the size of the common bile duct is used as the only criterion for exploration, many intraductal stones will be overlooked (Fig. 2).

Palpation of Stones.—Is the digital examination of the bile ducts an accurate method for determining the presence of intraductal calculi? The effectiveness of this method largely depends on the skill, experience, and thoroughness of the surgeon making the examination. If the stones are of medium size and if situated in the supraduodenal segment of the choledochus or the common hepatic duct, their presence is usually noted by palpation. Intrahepatic stones and those residing in the ampullary region often escape such recognition. Likewise, small calculi, gravel, and biliary sand lack sufficient substance to permit digital detection. In 100 consecutive choledocholithotomies we discovered only 81% of the calculi by palpation, and 19% were found by cholangiography, flushing, and routine exploration of the ducts. In many instances we have visualized intraductal stones by operative cholangiography and yet have been unable to confirm their presence by palpation (Fig. 2).

It is important to remember that intraductal calculi are often multiple and vary greatly in size. Palpation usually detects the larger stones but fails to discover the smaller ones which may be floating around in the ductal channels (Fig. 4). It is obvious, therefore, that palpation cannot be used as the sole guide in determining when all intraductal calculi have been removed. In 92% of the 110 cases in this series, in which intraductal calculi were overlooked, the surgeons were unable to recognize the stones by palpation, otherwise they would have been removed. Some of these ducts contained as many as 22 calculi, and in one instance the ampullary stone had a diameter of 4 cm.

There were seven cases in study in which the common bile ducts were definitely enlarged, but palpation failed to detect the presence of intraductal stones. The surgeons were led to assume that the icteric conditions were produced by the associated pancreatitis; hence, no instrumental explorations were employed. Progressive jaundice, combined with recurring colic, necessitated reoperations, and several small nonpalpable stones were removed from the ampullary zones (Fig. 5).

It is obvious that the presence of a palpable stone requires intraductal explorations, but the failure to "feel" stones within ducts must be accepted with great reservation.

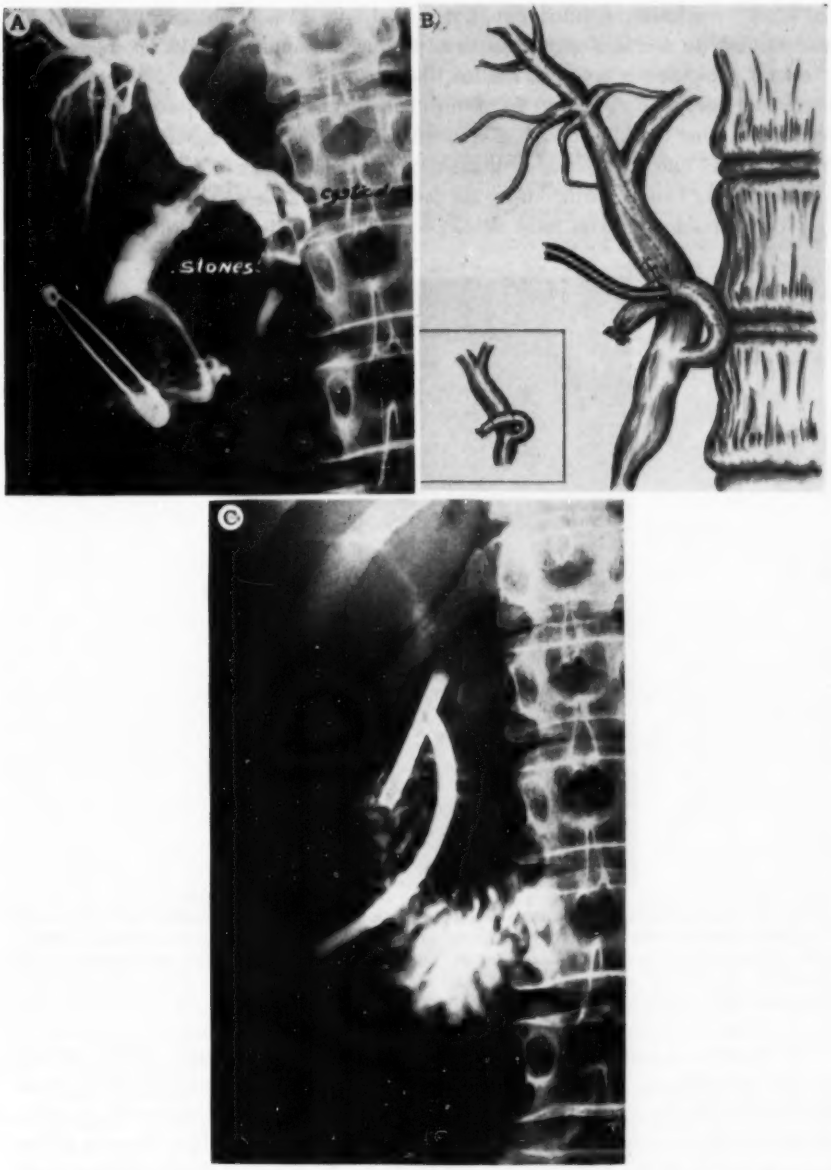

Fig. 4.—*A*, case in which cholecystectomy, choledocholithotomy, and insertion of T-tube drainage had been done 10 days earlier. The postoperative cholangiogram indicates that the T-tube was misplaced; the upper limb is in the common hepatic duct and the lower limb in an aberrant cystic duct. Note that the cystic duct, which passes anterior to the common hepatic duct, was mistaken for the choledochus and intubated. Residual stones can be seen in the cystic, common hepatic, and choledochal ducts. *B*, drawing showing conditions found at the second operation. Failure to appreciate existing anomalies accounted for the errors at the first operation. *C*, postoperative cholangiogram made six days after the secondary exploration. Ducts are patent and empty readily.

Jaundice.—Lahey pointed out that only 18 to 20% of intraductal stones are able to obstruct the flow of bile so as to produce a jaundiced state. It follows that if ductal explorations are reserved for those patients who have had a recognizable cholemia, more than three-fourths of intraductal stones will be missed at the primary operation. The bile ducts have a tremendous capacity for adaptation, and calculi measuring as much as 3 cm. in diameter may not produce a recognizable hyperbilirubinemia. This is borne out by the fact that only 21% of the 110 patients with residual intraductal stones have developed jaundice since their primary operation.

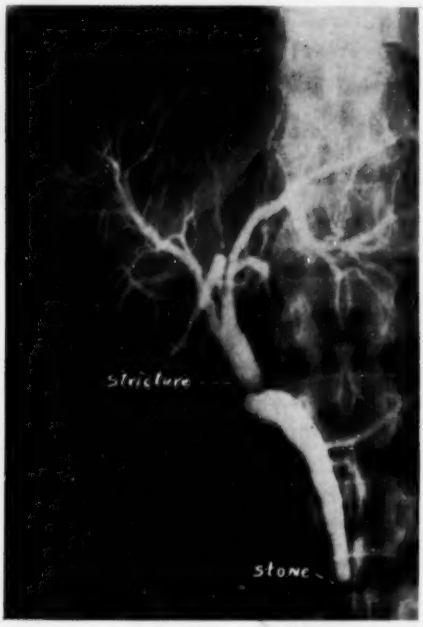

Fig. 5.—A persistent external fistula resulted from a cholecystectomy and choledocholithotomy. The postoperative cholangiogram outlines a stricture at the site of T-tube drainage, also a small stone wedged in the ampullary outlet. Convalescence from the primary operation was uneventful, except for the small fistula, and a second exploration was not performed until 18 months later.

If jaundice is used as a criterion for exploring the bile ducts, many patients will be subjected to unnecessary operations. Fully 75% of all hyperbilirubinemia is caused by conditions such as cirrhosis, hepatitis, infections, and malignant growths, which are not ammenable to surgical measures. Jaundice, therefore, denotes pathologic conditions of the hepatobiliary system without providing much evidence as to provocative factors.

PATHOLOGIC CONDITIONS CONTRIBUTING TO RESIDUAL STONES

Failure to remove all calculi when operating on the biliary system cannot be attributed solely to inexperience or to improper techniques, for often the pathologic processes themselves may present insurmountable problems.

Intrahepatic Calculi. — These have been found in approximately 7% of all cases of cholelithiasis (Best [2]). As a rule they escape detection at the primary operation because they are so deeply embodied in the liver substance that palpatory recognition is impossible. Fortunately, operative cholangiography affords an excellent method of visualizing these hidden calculi while the patient is still on the operating table (Fig. 6). There were five such cases in this series, and in only one instance were the stones removed (Fig. 7). The long, bifurcating, tortuous intrahepatic ducts defied instrumental exploration. Attempts to dislodge the impacted stones by means of alternating positive and negative ductal perfusions also failed. Hepatotomy was considered but not attempted because of the alarming hemorrhages which always accompany attempts to remove the stones by direct extirpation. Like-

Fig. 6.—The postoperative cholangiogram taken after cholecystectomy and choledocholithotomy outlines residual stones in left hepatic, common hepatic, and common bile ducts. This patient is well three years after the primary operation, despite the presence of choledochal stones.

wise, experience has taught that it is a most difficult task to find these elusive calculi by the transhepatic approach. At the present time, the problem of intrahepatic calculi seems unanswerable.

Small Stones.—The group of cases in which biliary sand, gravel, or very small stones were floating within the ductal system presented a formidable problem. The stones are too small and too numerous to be removed by grasping forceps or to be extracted with a scoop. They float around in the bile, and even profuse irrigations of the duct often fail to remove them completely. Rough instrumentation may embed them in the walls of the ducts so that they cannot be dislodged. When the process of ulceration finally liberates the incarcerated stone, it can again migrate up and down the duct and produce pain. Patience, gentleness, and thoroughness exercised during the operation improved the results but do not guarantee that all of these small irritating stones will be removed.

Diverticular Stones.—In some cases (three in this series) a stone becomes incarcerated in a diverticular pocket of the common duct. Such calculi do not obstruct the ductal channel, and hence both bile and the exploring probes may pass down the duct without indicating the presence of the calculus. If the stones are too small to be palpated, they will be overlooked entirely. Operative cholangiograms have been very useful in localizing these abnormally situated calculi.

Poor-Risk Patient.—Certain pathologic states forbid complete operations on the biliary tract unless the life of the patient is jeopardized. When the surgeon is confronted with an acute gangrenous gall bladder, a fulminating pancreatitis, or an intense jaundice, he is usually wise to forego an exploration of the ducts and to confine his procedure to decompression of the congested biliary system. In such circumstances, stones in the common duct are not "overlooked," but definitive treatment is purposely postponed until a more propitious time.

Fig. 7.—*A*, cholecystectomy and choledocholithotomy had been performed 10 days prior to this cholangiogram. A progressive jaundice, complicated by recurring colic, was caused by stones obstructing the ampullary outlet and occluding the left hepatic duct. *B*, five stones were removed at the second exploration. The postoperative cholangiogram demonstrates that the ducts are patent. Note how the long limb of the T-tube passes through the ampullary outlet into the duodenum.

CAN THE INCIDENCE OF RESIDUAL CHOLEDOCHAL STONES BE REDUCED?

Analysis of the cases collected in the present series permits two deductions: 1. "Overlooked" ductal stones result often from the inexperience of the surgeon. 2. Residual calculi may also result from the nature of the pathologic lesions already present. It follows that the errors of commission might be greatly reduced, but those caused by the diseases themselves must be accepted, at least for the present.

It is obvious that if the surgical errors are to be minimized, the surgeon who elects to operate on the biliary system must be conversant with the normal and abnormal anatomic patterns, both of the larger bile ducts and of the blood vessels

in the vicinity of the biliary tract. He must also have the proper instruments and be familiar with their use. He must be able to recognize the subdued vibrations of the scoop as it comes in contact with the stone; he must be adept in extracting soft calculi without causing fragmentation. Likewise, he must be conversant with the normal tone of the sphincter of Oddi so that he may interpret properly the resistances offered by spasms, impacted stones, or stricture formations.

If a surgeon performs but two or three operations on the biliary system each year, he has but little "feeling" and skill for this delicate work. The problems presented by lesions of the gall bladder and its adnexae require keen diagnostic acumen, sound surgical judgment, and excellent technical skill. These can be acquired only by extensive experience.

WHAT TREATMENT SHOULD BE GIVEN TO PATIENTS WITH "RESIDUAL" STONES IN THE COMMON BILE DUCT?

Attempts to remove residual calculi by nonsurgical methods, in general, have been disappointing. Pribram [3] developed a method for dissolving such stones by introducing ether into the common duct through drainage tubes. He believed that ether, a fat solvent, would extract the fatty components of the stones and cause them to crumble, thus permitting the detritus to be flushed through the ampullary opening into the duodenum. Sporadic reports have appeared in the literature confirming the efficacy of this method, but our experience has been otherwise. Fifteen patients with residual choledochal stones were subjected to treatment by this method of chemolysis. In only one instance did we succeed in dissolving the intraductal stones. At times the constitutional reactions were so severe that the patients refused to submit to a second trial. Apparently, the chemolytic properties of ether are meager when measured in terms of their ability to dissolve gallstones. We placed different types of stones in a test tube containing ether and left them for three weeks. There was little change in size, shape, or contour of the stones at the termination of this experiment. It follows that we cannot expect a transitory application of ether to accomplish more than an ether bath. This method of Pribram's has not proved effectual as a solution to the problem of residual choledochal stones.

In 1936 Best and Hicken [4] introduced the biliary flush as an effective method of mechanical removal of residual choledochal stones by washing them through the ampullary outlet into the intestinal tract. This procedure called for the complete relaxation of the sphincter of Oddi by the administration of effective doses of nitrites, followed by positive intraductal irrigations to force the stone into the duodenum. Twenty patients were subjected to this treatment, and the results were most disappointing. On one occasion, 11 small stones were recovered from the feces, all of which had been flushed from the common bile duct. As a rule, however, our attempts were unsuccessful.

Surgical Treatment.—Since the nonsurgical methods so far introduced have not proved to be satisfactory, it seems much better to place dependence on a thorough exploration of the bile ducts, in removing the troublesome stones overlooked or residual after primary operations on the gall bladder.

The follow-up studies in the present series indicated that secondary explorations were required in at least 75% of the 110 cases with residual stones for the correction of intraductal obstructions. It is interesting that 13% of the patients subjected to secondary procedures required surgical treatment because of severe

postoperative complications which developed while they were recovering from the primary exploration and that 68% did not require intervention until latent complications occurred.

Immediate Operations: These operations were mandatory in those persons suffering from progressive jaundice, those who had persistent vomiting, and those in whom a severe colic recurred. In these instances the progressive pathologic processes so jeopardized the lives of the patients that emergencies were presented, demanding prompt treatment.

When we have been confronted with such a problem, it has been our policy to obtain a preoperative cholangiogram before opening the abdomen. This is accomplished by injecting 10 ml. of iodopyracet (35% by weight) into the T-tube and then taking a roentgenogram. The film clearly outlines the anatomic position of the bile ducts, localizes the obstructive agents, and designates the number of calculi present (Fig. 4). When the abdomen is opened, the T-tube serves as a guide and is followed down to the obstructed ducts. After the common duct has been exposed carefully, the retaining sutures are gently removed, the T-tube is withdraw, and the ducts are reexplored through the original choledochal incision (Fig. 5). Such a plan minimizes additional trauma and tends to prevent periductal fibrosis and future formation of strictures.

Delayed Operations: In this series delayed operations were performed on 61 patients whose symptoms were so mild or latent that the secondary procedure was postponed for 3 to 18 months. This delay permitted the inflammatory reactions to subside, consequently, the necessary remedial measures could be executed more easily. In performing the secondary operation in such instances, we usually enter the abdomen to the left of the original incision so as to pass through nonfibrotic tissues; the absence of adhesions permits better visualization of important structures. By following the course of the stomach and duodenum, the hepatoduodenal ligament may be easily identified. An excellent view of the common bile duct can be obtained by careful reflection of the anterior leaf of this ligament. In some cases there may be considerable periductal fibrosis, and the resulting hemorrhages make it difficult to find the elusive choledochus. Occasionally, we incise the gastrohepatic ligament to the left of the portal system and try to identify the ducts from the posterior approach. If this maneuver fails, an exploring needle is gently inserted into the hepatoduodenal ligament until bile can be aspirated. When this is accomplished, 10 ml. of iodopyracet is injected into the bile ducts, and a visualizing cholangiogram is made. With this roentgenographic guide, there need be no difficulty in locating the common bile duct; consequently, remedial procedures can be employed.

In the series studied, not all secondary operations were successful, for 12 patients had three or more explorations. One patient submitted to five explorations before the elusive calculi were removed. Seven patients had had their ducts so traumatized by repeated explorations that some type of ductal transplantation had to be employed. Such facts indicate that only those trained in surgery of the bile ducts should attempt these secondary operations.

Twenty-nine patients with intraductal stones refused additional operations. Twenty-one of these were free from symptoms and could see no reason for being subjected to another operation. Eight patients had symptoms indicating the need for

surgery, but refused treatment. It is easy to understand the attitude of those who are symptom-free; in the occasional instance, as exemplified in the case shown in Figure 6, a long period elapses without further trouble. Nevertheless, we believe that these "silent stones" are dangerous and should be removed before they provoke serious symptoms. It is common knowledge that intraductal calculi irritate the mucosal lining of the ducts and thus promote fibrosis. They interfere with the free flow of bile and thus produce stasis, and they constantly traumatize tissue and thus invite infection. These conditions tend to produce more stones. For example, in one of our cases the postoperative cholangiogram clearly outlined a solitary stone located in the ampulla of Vater. We advised that it be removed, but the patient felt so well that she refused operation. Six months later, she sought relief from an intense jaundice. Five stones were removed from the common bile duct, and it seems reasonable to assume that four of these stones were formed after the primary operation, since only one was visualized in the original cholangiogram (Fig. 7). This case demonstrates that delay invites trouble. Operation is much easier to perform when the extrahepatic biliary system is healthy than it is after severe complications have developed. The "silent" intraductal stone invariably produces trouble, and time is the only factor needed to insure its appearance.

SUMMARY

In this study of 110 patients observed in 11 hospitals, residual stones in the bile ducts following primary operations on the extrahepatic biliary system were determined by postoperative cholangiography. Our prime interest was concerned with two questions: (1) Why were these stones missed at the primary operation, and (2) what clinical course did these patients with residual stones follow?

The original operations on the 110 patients were performed by 26 different surgeons, the majority of whom were occasional operators and the others well trained. The incidence of residual choledochal stones was 10 times as great in the 25% of patients who had cholecystectomies performed by inexperienced surgeons as in the 75% of patients operated upon by specialists.

The failures of the inexperienced operators were attributable to (1) unfamiliarity with the abnormal ductal and vascular patterns; (2) inability to cope with hemorrhage; (3) failure to interpret properly the need for ductal explorations, and (4) inexperience with choledochal instrumentation.

Certain pathologic conditions prevented complete operations during the primary approach, such as acute cholecystitis, fulminating pancreatitis, intrahepatic stones, and patients whose general condition made them poor risks. Even the experienced surgeons were compelled to adopt conservative procedures when confronted with these difficulties.

This study demonstrates that the postoperative clinical course affords no index as to the completeness of the primary operation. Only 13% of the patients required a second laparotomy during the initial hospitalization, while 87% were discharged as cured. Only 21% of the patients later developed jaundice, even though some of them were followed for 10 years or longer. Nevertheless, 81% of the 110 patients eventually required secondary operations; in 7, plastic operations were necessary to improve the flow of bile.

CONCLUSIONS

1. To eliminate the errors in gall-bladder surgery which account for the majority of cases of residual choledochal stones, special training, skill, and experience are necessary. Every surgeon who elects to remove the gall bladder should be qualified to perform procedures involving the bile ducts.

2. All secondary operations on the extrahepatic biliary system should be done by surgeons of experience because of the intricate and complicated problems encountered.

3. The segregation, preoperatively, of those patients requiring intraductal explorations, unfortunately, cannot always be determined by clinical signs and laboratory tests. The surgeon, therefore, must be prepared to cope with any conditions encountered.

4. Cholangiography is transforming surgery of the biliary tract from a haphazard procedure to an exact science. Operative cholangiography is useful in determining ductal abnormalities, in localizing the site and nature of the ductal obstructions, in determining the potency of the ducts, and thus furnishing a guide as to the need for ductal explorations. Postoperative cholangiography provides information concerning the completeness of the primary operation, by visualizing ductal abnormalities, if present.

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TRAUMATIC RUPTURE OF THE THORACIC AORTA

Review of Literature and Case Report

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TRAUMATIC rupture of the thoracic aorta is rare, but even more unusual are reports of long survival with this lesion. Because of the long survival in this particular case and the possibility that some of these unfortunate patients may be saved, this paper is presented.

One reason for the lack of knowledge concerning this lesion lies in the fact that most cases are diagnosed only at necropsy. The rapid state of shock and coma in

Summary of Cases of Aortic Rupture

Author	Number	Location	Duration of Life After Injury
Automobile Accident			
Tannenbaum and Ferguson [5]	2	Isthmus	35 min.
McDonald [6]	2	Isthmus	D.O.A.*
Rice [2]	1	Isthmus	20 days
Strassmann [1]	72	40 at isthmus	18 hr.
Kastl [7]	1	Isthmus	10 days
Struck by Automobile or Flying Object			
Kuhn [8]	1	Ascending aorta	10 days
Landau [9]	1	Ascending aorta	1 day
Kemp [10]	11	Ascending aorta	1 day
Kleinsasser [11]	1	Isthmus	D.O.A.*

* Dead on arrival.

which the patient remains until death, plus the concomitant severe injuries in other parts of the body, make the diagnosis during life very difficult.

Strassmann [1] reports on 72 cases of traumatic aortic rupture from approximately 7,000 autopsies done from 1936 to 1942 at the Chief Medical Examiner's Office in New York City. In this series, 42 patients were less than 50 years old and except for the results of trauma showed no visible gross pathologic change in the aorta. The aortic rupture in 51 patients was the result of an automobile accident (Table). The most frequent site of rupture was at the isthmus, just below the

From General Surgery Section (Captain Jay) and Thoracic Surgery Section (Colonel French), Department of Surgery, Walter Reed Army Hospital, Walter Reed Army Medical Center, Washington 12, D. C. Colonel French's present address is Letterman Army Hospital, San Francisco.

origin of the left subclavian artery. This occurred in 40 patients. In many of the patients in this series, there was little evidence of injury to the chest wall. Some did not even suffer fractured ribs. The cause of death in most instances was severe hemorrhage through the ruptured area or from injury to other organs. Most patients developed mediastinal hemorrhage and/or hemothorax. Fifty-nine died within one hour, and only four lived 12 to 18 hours after injury. The longest survival reported in the literature was 20 days.[2]

Arteriosclerosis does not seem to play an important role, as is indicated by the low age range and lack of gross or microscopic evidence.

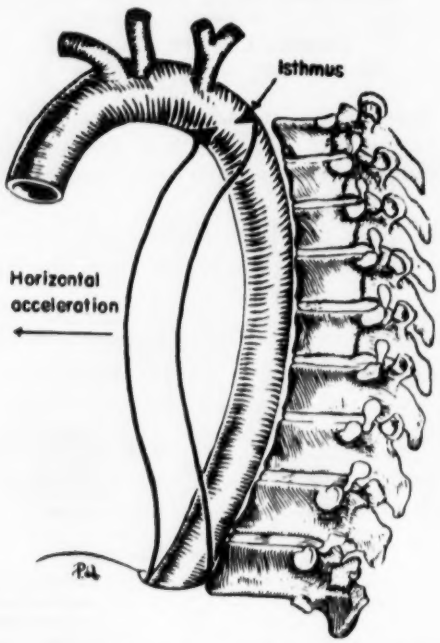

Fig. 1.—Horizontal acceleration throws the mobile thoracic aorta forward, exerting maximum stress at the isthmus. The relation of the great vessels emerging from the aortic arch are reversed in this sketch.

It is interesting to speculate on how the aorta may be ruptured with relatively little evidence of external damage to the chest wall. In 1893, Prof. Eduard Rindfleisch,[3] of Wurzburg, first showed that relative fixation of the aorta occurs where the great vessels originate, and distal to these locations the aorta is relatively mobile. He stated that the portions which are relatively fixed are most likely to rupture.

From his studies of injuries in aircraft accidents, Hass [4] concluded that whenever one part of the body is decelerated at a rate different from that of another, the connections between the two parts are placed under stress which is proportional to the difference in the rate of deceleration. In the aorta, the connection between the relatively mobile descending portion and the fixed arch is the area of the isthmus,

or just below the left subclavian artery. In cases of rapid deceleration the patient is momentarily subjected to very large forces which may be resolved along three principal axes—horizontal, vertical, and lateral. Horizontal forces result in the tearing of the aorta at its fixed position and vertical forces result in the bursting of the aorta

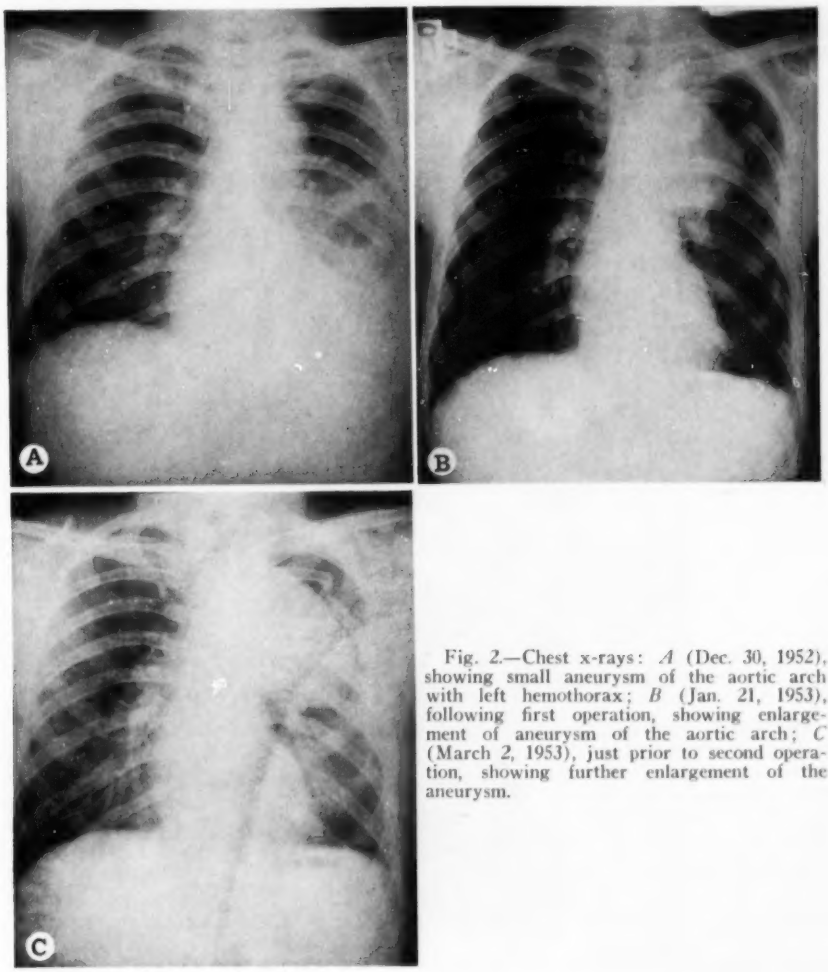

Fig. 2.—Chest x-rays: *A* (Dec. 30, 1952), showing small aneurysm of the aortic arch with left hemothorax; *B* (Jan. 21, 1953), following first operation, showing enlargement of aneurysm of the aortic arch; *C* (March 2, 1953), just prior to second operation, showing further enlargement of the aneurysm.

at its weaker portions, namely at the isthmus and just above the aortic valves. This latter is caused by the enormously increased intravascular pressure.

During deceleration of the thorax the mobile descending aorta is slowed at a rate different from that of the fixed arch. The descending aorta, with its column of blood, is thrown forward, exerting a tremendous stress on the connection between the fixed arch and the mobile aorta, namely the isthmus (Fig. 1).

REPORT OF A CASE

A 20-year-old white man was involved in a head-on automobile collision on June 30, 1952. He was thrown to the floor and suffered a fractured jaw and right femur, plus cerebral concussion and contusions of the anterior chest wall. For two to three months following the accident he had anterior pleuritic chest pain and aching between the scapulae, especially when lying on the

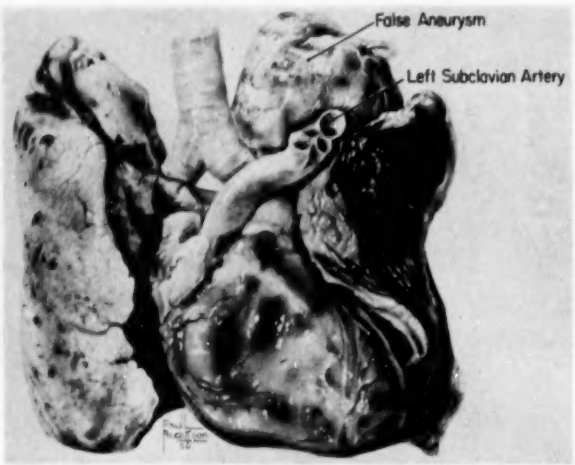

Fig. 3.—Anterior view of autopsy specimen, showing location of aneurysm.

Fig. 4.—Posterior view of autopsy specimen, showing location of aneurysm.

left side. There were no bruises on the chest wall, nor were the ribs fractured. His fractured jaw and femur were treated with good result at an Air Force hospital, and he was discharged on Nov. 20, 1952. It is to be noted that the patient spent most of the first three months after injury at absolute bed rest.

About Dec. 22, 1952, the patient began to cough up small amounts of brownish sputum. On Dec. 29, while on duty as a meat cutter, he lifted a 200-lb. (91 kg.) carcass, at which time he experienced a sudden onset of dyspnea, faintness, and a feeling that he was about to die. He

did faint for a few minutes, and was later admitted to an Air Force hospital with a massive left hemothorax and in shock. After resuscitation, fluoroscopy revealed a pulsating mass in the region of the aortic arch. A soft systolic murmur was heard over the left second interspace, anteriorly. On Jan. 7, 1953, the patient complained of severe boring thoracic and lumbar pain. A chest x-ray revealed a massive left hemothorax. A left thoracotomy was performed through the fifth rib. At this time, 2,000 cc. of dark blood was evacuated and 2 cm. distal to the left subclavian artery a 4-cm. aneurysm of the aortic arch, densely adherent to the apex of the lung, was located. The lung was partially stripped from the aneurysm, but because of the possibility of rupturing this friable aneurysm, further dissection was abandoned. The patient did well postoperatively and it was decided to wait for collateral circulation to develop before attempting a graft. However, on Feb. 17, 1953, the patient coughed up one-half cup of blood, and a chest film revealed the mass to be enlarging. Because of this he was transferred to Walter Reed Army Hospital for a possible arterial homograft.

Physical Examination.—A soft systolic murmur was heard in the second and third anterior left interspace and, posteriorly, 1 to 2 in. (2.5 to 5 cm.) above the angle of the left scapula. Blood pressure in both arms was 160/90; legs, 152/118. All peripheral pulses were full and equal. A chest x-ray on February 26, revealed no enlargement as compared with the film of February 17 (Fig. 2).

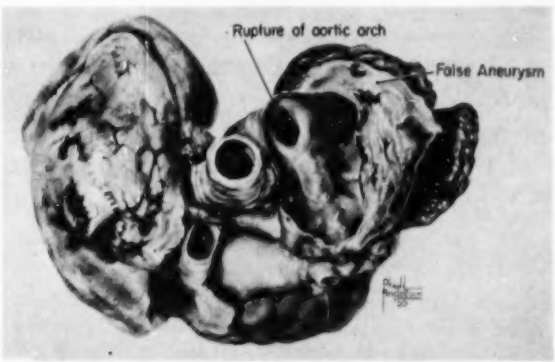

Fig. 5.—Superior view of autopsy specimen, showing location of aneurysm.

While awaiting the arrival of a suitable graft, the patient had several episodes of hemoptysis; none of these was massive. On March 11, a left thoracotomy was done through the previous incision. This revealed an 8- by 10-cm. solid pulsatile mass extending from the innominate artery to 7 cm. above the diaphragm and extending upward into the root of the neck. The aneurysm extended laterally to the posterior axillary line, where it was adherent to the chest wall. The lesion was deemed inoperable, and the chest was closed. The patient did fairly well postoperatively until April 21, when, while sitting quietly by his bed, he suddenly developed a paroxysm of coughing with massive hemoptysis of bright red blood and died.

Postmortem examination revealed a 2-cm. defect with smooth margins on the lateral aspect of the aorta 4 cm. below the left subclavian artery. This led into a 6- by 8-cm. false aneurysmal sac which extended between the upper and lower lobes and was adherent to the posterior lateral chest wall. The sac was largely filled with laminated clot. Death was due to erosion and rupture into a medium-sized bronchus (Figs. 3, 4, and 5).

Microscopic slides revealed a normal aorta. No evidence of arteriosclerosis or cystic medial necrosis was found.

SUMMARY

A review of the literature on traumatic aortic rupture is presented. Most cases are due to rapid deceleration of the thorax with maximum stress and a tear located just below the left subclavian artery. Few long survivals have been reported. The

patient reported here survived nearly 10 months with a 2-cm. defect at the isthmus. His survival apparently was based on the formation of a false aneurysmal sac during enforced bed rest for treatment of a femoral fracture.

In retrospect, it is believed that perhaps this lesion should have been resected and repaired as soon as it was discovered.

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DEFIBRILLATION OF THE VENTRICLES UNDER HYPOTHERMIC CONDITIONS

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THE SUGGESTION of Bigelow [1] that hypothermia might be used as an aid to intracardiac surgery has excited the interest of many surgeons. Like others, we have stopped the circulation of a group of dogs under hypothermic conditions and have performed experimental intracardiac operations. Also like others, we have found that ventricular fibrillation may seriously limit the usefulness of this technique. It is a relatively frequent complication and one which is not always readily overcome. Factors which probably contribute to the high incidence of fibrillation are (1) anoxia, (2) manipulation of the heart, and (3) hypothermia. It has been our impression that it is more difficult to abolish ventricular fibrillation in hypothermic than in normothermic dogs. The experiments described below were undertaken in an attempt to find out whether this impression could be confirmed under controlled conditions.

METHODS

During experiments recently reported[2] we developed a standardized technique for inducing and abolishing ventricular fibrillation in normothermic dogs. Fibrillation was induced by passing a current of 10 volts through the heart for 0.50 second. The heart was allowed to fibrillate for four minutes before institution of resuscitative measures. It was then compressed at a rate of 80 times per minute for two minutes, and the defibrillating shock was applied. Single, 0.10 second shocks were used. The strength of the initial shock was varied between 110 and 270 volts in different series of animals. Increasingly stronger currents appeared to be increasingly effective. Single shocks of 220 and 270 volts were almost invariably successful. Most of the dogs survived until killed, and there was no evidence of myocardial burns at autopsy. The results of these experiments with anoxic, normothermic hearts appeared to provide suitable controls for experiments with hypothermic hearts.

The details of the present experiments were as follows: Dogs were anesthetized with intravenous sodium pentobarbital (25 mg. per kilogram). An endotracheal tube was inserted, and the lungs were ventilated with 100% oxygen. The body temperature was then lowered by surrounding the dogs with chipped ice. This usually brought the rectal temperature down to 26 C. within an hour. An additional 30 minutes was sometimes required to lower the temperature to 20 C. The temperature usually fell an additional 2 to 4 degrees (C.) after the ice was removed. Allowance was made for this additional drop in planning the time of removal. The left chest was entered through the fifth or sixth intercostal space, with the dog in the lateral position, and the pericardium was opened widely. Ventricular fibrillation was induced with a 0.50 second shock of 10 volts. The heart was allowed to fibrillate for four minutes and was then compressed for two minutes at a rate of 80 times per minute. The defibrillating shock of 220 volts was then applied for 0.10 second. If the normal heart beat was restored, no further therapy was given.

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If fibrillation was not abolished, the heart was compressed for another minute and the shock was repeated. When fibrillation still persisted, serial 0.10 second shocks were applied after an additional minute of cardiac compression. If the initial stock abolished fibrillation but the heart went into standstill, it was observed for a period of 10 to 20 seconds to see whether it might begin to beat spontaneously. When it did not, the heart was compressed intermittently until it was beating on its own. Epinephrine hydrochloride (0.30 cc. of 1 : 1,000 solution) was injected into the right auricle if strong, spontaneous heart beats did not resume after 15 minutes.

When it appeared relatively certain that contiued effective spontaneous heart action could be anticipated, the chest wall was closed in layers. Oxytetracycline (Terramycin) was administered intravenously during the operative procedure. The animals were partially immersed in a basin of water at 45 C. for rewarming. The rectal temperature usually returned to 38 C. within an hour. Postoperative care was routine and did not differ from that for other dogs in the colony. The animals were carefully observed during the first few postoperative days for evidence of cerebral or cardiac injury. They were killed within 10 days after operation, and the hearts were examined carefully for evidence of burns or other injuries at autopsy.

The number of dogs cooled and operated upon was 24. Ventricular fibrillation occurred "spontaneously" in one whose chest had been opened at 26 C. The pericardium had not been opened and the heart had not been manipulated any way. The rectal temperature at the time fibrillation was induced was 26 C. in 17 animals, 24 C. in two, 23 C. in one, and 20 C. in three.

RESULTS

The response of the fibrillating heart to a single, 0.10 second shock of 220 volts was not essentially different from that of normothermic dogs in 9 of the 17 animals at 26 C. Ventricular fibrillation was abolished and regular sinus rhythm resumed. There was usually a definite, observable period of asystole before the first heart beat in the hypothermic dogs, however. This was in contrast to normothermic dogs, in which the first cardiac contraction usually followed the electric shock so closely that a period of asystole was not observable.

In the remaining eight dogs at 26 C. the response to the defibrillating shock was distinctly different from that usually observed in normothermic dogs. In five of these eight animals, ventricular fibrillation was promptly abolished but the heart remained in asystole. After 10 to 20 seconds of cardiac standstill, cardiac compression was begun. One or two compressions usually stimulated the occurrence of a strong ventricular contraction. This was followed by another period of standstill. It was necessary to compress the heart intermittently for 10 to 15 minutes before the heart appeared capable of maintaining adequate circulation independently. Epinephrine hydrochloride (0.30 cc. of 1 :1,000 solution) was injected into the right auricle of two of the animals because of persistence of weak contractions. The contractions eventually became stronger, but whether the epinephrine made a significant difference cannot, of course, be stated with certainty. Ventricular fibrillation did not recur in any of the animals with prolonged periods of asystole.

Ventricular fibrillation was not abolished by the test defibrillating shock in the other three animals at 26 C. In one, a repeat shock after an additional minute of cardiac compression was successful. In the other two, three single shocks, alternated with periods of cardiac compression, were not successful. Serial, 0.10 second shocks were finally effective, and the spontaneous heart beat had to be supported with cardiac compression in both of these animals.

Ventricular fibrillation was abolished by the test shock in the animals at 24 and 23 C. A brief period of support was necessary for one of the animals at 24 C.

Repeated single shocks of 0.10 second did not abolish fibrillation in any of the three animals at 20 C. Serial shocks were eventually successful in all three. Cardiac compression was necessary in two because of long periods of asystole.

Two of the animals did not regain full consciousness and died within 24 hours after operation. There was trouble with the ventilation apparatus after the heart was shocked in both instances, and these dogs probably died of irreversible anoxic damage to the brain. No specific changes were noted at autopsy. All other animals lived until killed and showed no evidence of cerebral or cardiac abnormalities while alive. Three instances of severe wound infection and empyema were found at autopsy. There were areas of consolidation in the lungs in many instances, as is commonly the case, in our experience, when dogs are killed within 7 to 10 days after operation. The hearts appeared grossly normal in most instances. A few had areas of subendocardial ecchymosis, presumably as the result of the trauma of cardiac compression. In two instances of serial defibrillation, there were definite, grossly evident electrode burns.

COMMENT

It is well established that hypothermia increases the incidence of ventricular fibrillation. There is no additional evidence concerning this point in these experiments except that fibrillation developed in one instance before the heart was touched. The technique used for inducing fibrillation is nearly always effective under both hypothermic and normothermic conditions.

Whether defibrillation of the ventricles is more difficult to accomplish under hypothermic than normothermic conditions has not been previously studied to our knowledge. Others have stated [3] that the difficulty does not seem appreciably greater. There is no doubt that, under the conditions of these experiments, the difficulty was distinctly greater. There was greater difficulty in abolishing fibrillation and also in getting the heart to beat regularly after fibrillation was stopped. The problems encountered in these experiments appeared to be the same as those in fibrillation occurring during cardiotomy with the cavae occluded under hypothermic conditions.

SUMMARY

Experiments were performed in dogs to determine whether it is more difficult to abolish ventricular fibrillation by electric shock in hypothermic than in normothermic dogs.

Ventricular fibrillation was found to present greater difficulties under hypothermic conditions in two ways: (1) there was more frequently difficulty in stopping it, and (2) the ensuing cardiac asystole was more frequently difficult to overcome.

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CYSTOGASTROSTOMY FOR PANCREATIC CYST

Report of a Case

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THE ANASTOMOSIS of a pancreatic cyst to the stomach is a rare operative procedure, having been reported 55 times in the world literature. The majority of the authors have reported one case, and very few over two cases. Recently, we have had a case in which this type of anastomosis was performed with seemingly good results. We should like to review the etiology of pancreatic cysts, the means of diagnosis, and the treatment of pancreatic cysts, together with a description of our case treated by cystogastrostomy.

There is no question but that the ideal treatment of a pancreatic cyst is removal *in toto*, but, unfortunately, there are occasions when, because of either the general condition of the patient or the size of the cyst, complete extirpation is hazardous or technically impossible. The extremely large pancreatic cyst (pseudocyst) lying within the omental bursa and intimately associated with and adherent to nearby vital organs and structures cannot be removed, even under the best of conditions.

In general there are four methods of dealing with this type of cyst:

1. Complete extirpation
2. Marsupialization
3. Anastomosis of the cyst with some part of the upper gastrointestinal tract
4. Partial pancreatectomy

Although pancreatic cysts are not a common finding, they are of frequent enough occurrence to warrant study of their proper diagnosis and effective treatment. We know that it is mandatory to remove cysts that may possibly undergo malignant degeneration, such as cystadenomas. Therefore, in question of doubt at the operating table, a biopsy and frozen section is in order.

In the July, 1953, issue of the *Annals of Surgery*, Zaoussis,[88] of Athens, Greece, reported five cases of anastomosis of pancreatic pseudocysts to the stomach, bringing the total reported to that date to 55 cases. The first case had been reported by Jedlicka, in 1923.

That some definite treatment must be carried out is agreed by everyone, as usually these cysts attain such a size as to cause discomfort or distress. The patient with a cyst seeks out medical treatment for relief of specific complaints. Failure to treat a cyst surgically allows eventually for possible rupture intra-abdominally,

with attendant shock, peritonitis, or hemorrhage; or symptoms of gradual intestinal obstruction secondary to pressure of the cyst on the stomach or small bowel, or eventual death of the patient due to cachexia.

In 1929 Jurasz [39] altered the operation first suggested by Rudolph Jedlicka to one in which the cyst was anastomosed by a wide anastomosis with the posterior gastric wall by means of a transgastric approach. In the latter operation the anterior stomach wall is opened by means of a transverse incision and the pancreatic cyst is evacuated by means of a trocar passed through the posterior gastric wall. An incision is then made through the posterior stomach wall and the adherent pancreatic cyst wall, after which an anastomosis is made between the two walls, thus creating adequate drainage of the cyst into the stomach. After the anastomosis the anterior stomach wall is closed. Kunc [46] has recently reported three cases dealt with in the above manner with excellent postoperative results and with complete disappearance of the patient's symptoms.

The procedure of pancreatocystogastrostomy would actually appear as a rather illogical method of handling such a condition. One naturally wonders about the effect of the gastric juices and gastric contents upon the interior of the pancreatic cyst cavity, with the possible sequelae of infection, hemorrhage, and necrosis of pancreatic tissue. As a matter of fact, studies have proved that this does not take place and that, because of a reflex spasm [46] at the site of the anastomosis and because of the peristaltic waves of the stomach wall and the resultant sucking action on the contents of the cyst, the reverse occurs; that is, the cystic cavity empties by the drainage of its contents into the stomach. Barium meals have been given to patients who have had anastomosis of a pancreatic cyst to the stomach, and the roentgenological observation at time intervals of six days to eight years postoperatively has failed to show any evidence of the passage of barium into the cyst.* Zaoussis [88] advocates keeping the patient prone for several days postoperatively in order to facilitate emptying of the cyst into the stomach.

Pancreatic cysts are most usually differentiated as true cysts and pseudocysts, depending upon the etiology and whether or not the cyst has an epithelial lining. True cysts are those that are usually lined by epithelium or surrounded completely by pancreatic tissue. A pseudocyst is that which is most usually caused by trauma or by repeated attacks of pancreatitis and has a characteristic localization in either the lesser peritoneal sac, between the stomach and the liver, or between the leaves of the mesocolon. It may, at times, be difficult to differentiate between a true cyst and a pseudocyst, as a true cyst may eventually lose its epithelial lining and give the same appearance as a pseudocyst. The treatment in either case would involve the same considerations.

It is believed that the greater percentage of pancreatic cysts are caused by an attack of acute pancreatitis or by recurrent attacks of pancreatitis or a late development of chronic pancreatitis.

It is of interest to note that the injury to the abdomen causing a pancreatic cyst need not be a severe one. From previously reported cases the observations have been made that the injury to the abdomen was a minor blow and that this was sufficient to cause a pancreatic cyst. A blow to the abdomen that causes contusion, hemorrhage, or laceration of the pancreas, permitting the outpouring of pancreatic

* References 1, 17, 46, and 71.

juices and its resultant inflammatory reaction, may give rise to a pancreatic cyst. All cysts resulting from trauma are usually pseudocysts, a portion of their wall being formed by the lesser peritoneal sac or mesocolon.

The usual presenting complaint of a patient with a pancreatic cyst is abdominal pain. This pain is usually localized in either the right or the left hypochondrium or the epigastric area and in many cases is referred to the back. The pain is described as dull or aching in character or as an extremely severe pain, requiring analgesics. The patient may complain of such symptoms as anorexia, indigestion, eructation,

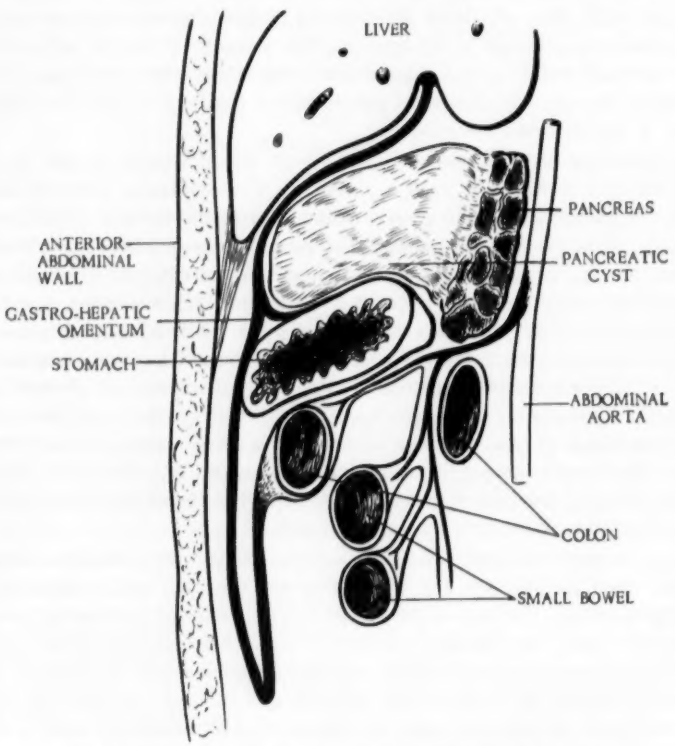

Fig. 1.—Sagittal section showing cyst between stomach and liver.

nausea, and vomiting, all of which are usually related to the pressure of the cyst on either the stomach or the small and large bowel. When chronic pancreatitis is the etiology of the cyst, one may also have the signs and symptoms of pancreatic insufficiency.[72]

Abdominal examination usually reveals the presence of a large mass located above the level of the umbilicus in either the right or the left hypochondrium, depending upon its location in the pancreas. It is relatively immobile and somewhat tense.

The x-ray examination is one of the best diagnostic aids in the diagnosis of pancreatic cysts. This condition may be suspected by a slight opacity in the epigastric

area of the abdomen or by the presence of an enlarged or widened duodenal loop [35] or a filling defect of the stomach, duodenum, or transverse colon caused by an extrinsic mass. Gastric pneumograms may be helpful.[70] Barium enema may be of aid in revealing further displacement of surrounding organs. Pancreatic cyst must be differentiated from a hydrops of the gall bladder, omental or mesenteric cyst, hydronephrosis, a retroperitoneal tumor, a tumor or cyst of the liver or cyst of the spleen, or aneurysm.

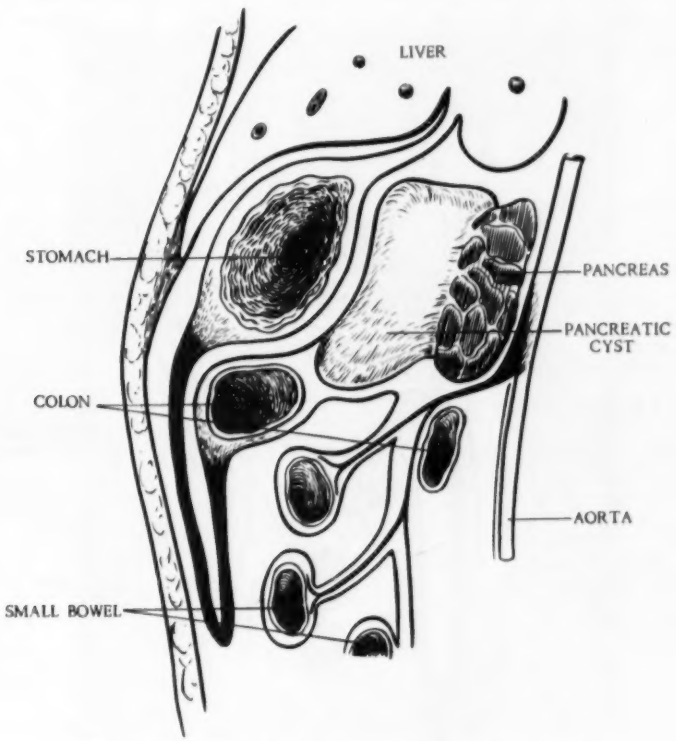

Fig. 2.—Sagittal section showing cyst posterior to stomach.

The laboratory studies may show evidence of mild diabetes with abnormal glucose and insulin tolerance curves, free fat in the stools, and a decreased quantity of the pancreatic enzymes in duodenal drainage specimens.

The contents of pancreatic cysts may be old blood or a clear or dark fluid containing necrotic debris. Pancreatic enzymes, such as trypsin and amylase, can usually be found, although absence of these enzymes does not rule out the presence of a pancreatic cyst.

The commonest site of a pancreatic cyst is between the stomach and the liver or protruding into the lesser peritoneal cavity, behind the stomach. These two common sites are illustrated in Figures 1 and 2.

Some pancreatic cysts are known to invaginate between the layers of the mesocolon, and, when they do, they usually present behind the transverse colon. Anatomically, the layers of the transverse mesocolon separate along the pancreas and cover its anterior surface. This site is illustrated in Figure 3.

REPORT OF A CASE

C. L., a 43-year-old white woman, was admitted to the Sancta Maria Hospital, Cambridge, Mass., on April 8, 1951, with a chief complaint of epigastric pain of one year's duration. In 1938 she had a cholecystectomy and had been under treatment for diabetes mellitus since 1941. X-rays at a well-known clinic shortly after the epigastric distress, showed evidence of a pancreatic cyst.

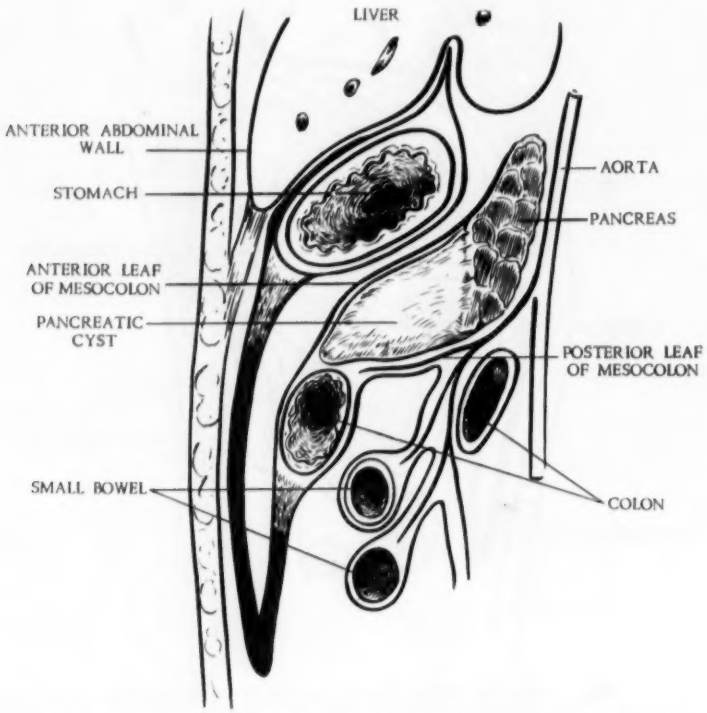

Fig. 3.—Sagittal section of pancreatic cyst invaginating between layers of transverse mesocolon.

At the time of admission, she was taking 30 units of protamine zinc insulin and 8 units of crystalline insulin daily. The blood sugar was 108 mg. per 100 cc.; blood amylase, 50 Somogyi units; serum sodium, 141 mEq. per liter, and potassium, 3.6 mEq. per liter.

Examination revealed a well-nourished and well-developed 43-year-old white woman in no acute distress. The lungs were normal to auscultation and percussion. The heart was not enlarged, and no abnormal sounds were heard. In the abdomen there could be palpated a grapefruit-shaped mass which was smooth in outline in the epigastrium and moderately soft but was nonmovable. It was found to be just to the left of the midline. The only part of the mass that could be palpated was the dome. The reflexes were physiological, and the extremities were negative.

PANCREATIC CYSTOGASTROSTOMY

The diagnosis of pancreatic cyst was made, and on April 9 a pancreatic cystogastrostomy was carried out as follows: When the abdomen was opened, there presented in the wound a huge cystic mass about the size of two grapefruits and protruding through the gastrohepatic omentum, as illustrated in Figure 1. Further exploration revealed that the mass was adherent to the undersurface of both lobes of the liver, the aorta, the body and head of the pancreas, the common hepatic duct, and the transverse mesocolon. The cyst was found to contain approximately 600 cc. of a thick gray fluid in which floated large sections of friable grumous material. It was noted on opening the cyst that there were small areas of fat necrosis studding its interior. The walls of the cyst were thick, being several millimeters in thickness. It was

Fig. 4.—Roentgenogram of cyst. Note displacement of stomach (with trace of barium) distally by huge pancreatic cyst.

observed that the left lobe of the liver was extremely small, probably as the result of pressure atrophy.

The abdomen was opened through a left subcostal incision about 6 in. (15 cm.) in length, parallel to the left costal margin and about 2 in. (5 cm.) below it. In view of the extensiveness of the mass and the fact that the patient had moderately severe diabetes, it was decided that the procedure of choice should be a cystogastrostomy. Inasmuch as the dome of the cyst was protruding through the gastrohepatic omentum, it was decided that the anastomosis should be carried out at that point. The dome of the cyst was anastomosed to the anterior border of the lesser curvature of the stomach just below the left gastric vessels. The posterior suture line consisted of interrupted lateral mattress (black silk) sutures. The cyst was aspirated and a wide anastomosis between the dome of the cyst and the anterior stomach wall made. When

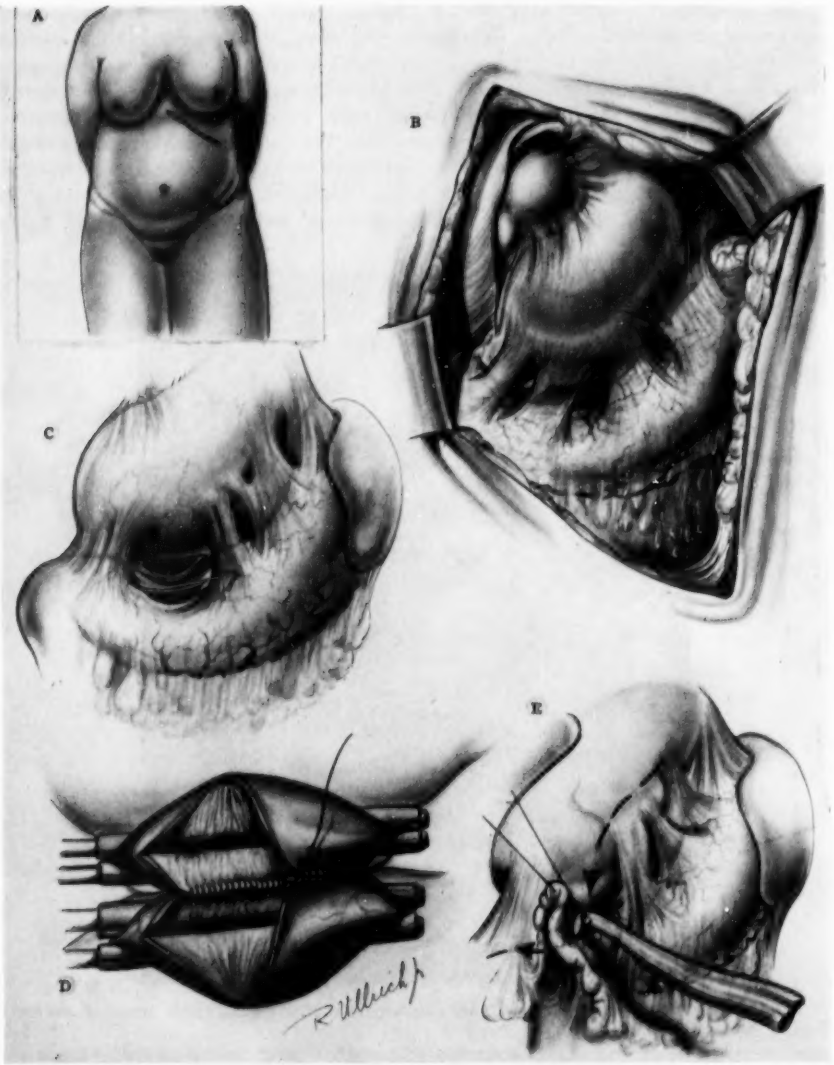

Fig. 5.—*(A)* Left hypochondrial incision running 1 in. (2.5 cm.) below and parallel to the left costal margin from the xyphoid to the left anterior axillary line. *(B)* Huge pancreatic cyst protruding through the gastrohepatic omentum and resulting in marked "thinning out" of same. Note the small size of the left lobe of liver, secondary to pressure atrophy and the displacement of the stomach distally. *(C)* The most advantageous site for anastomosis of this type of pancreatic cyst to the stomach is clearly demonstrated at its most dependent point; consequently, the cyst is usually empty when the patient is in the erect position. *(D)* A section of the cyst wall is removed, and the anastomosis is completed with a double row of silk and surgical gut sutures to prevent leakage. *(E)* The anastomosis completed, the junction is reinforced or buttressed by suturing around it the large omentum. Arrows indicate direction of flow of the liquid contents of the cyst into the pylorus. A cigarette drain is placed down to the anastomosis in the event of leakage.

the anastomosis had been completed, it was found that it easily admitted two fingers. The angles of the anastomosis were buttressed by suturing into the angles sections of large omentum (Fig. 5).

Penicillin, 200,000 units, was instilled into the abdominal cavity and the abdominal wound closed. Just prior to the closure a large cigarette drain was placed through a stab wound in the left flank, down to the region of the spleen. Levin-tube drainage was instituted for two days, and on the fourth postoperative day a postgastrectomy diet was started. The patient was encouraged to lie in the prone position in order to aid mechanically the emptying of the pancreatic cyst.

Postoperatively the patient had a stormy course in that she was distressed by nausea and vomiting frequently for a period of two weeks. She complained often of a "sickish sensation." It was learned that forcing fluids by mouth aggravated her distress. Therefore it must be assumed that distention of the stomach with liquids dilated not only the lumen of the stomach itself but also the cyst.

The patient was discharged on April 28, much improved and on a full diet. The amylase activity of the liquid contents of the cyst was reported as 46 Somogyi units.

COMMENT AND SUMMARY

It is apparent from the above review that surgical intervention is indicated in every case of suspected or proved pancreatic cyst. Conservative therapy, because of the untoward sequelae, has proved to be unsatisfactory. One cannot determine prior to laparotomy whether one is dealing with a carcinomatous degeneration of a cyst. Conservative therapy is also contraindicated because of the possibility of rupture of the cyst into the peritoneal cavity, with the attendant mortality of approximately 60%.[44]

It is agreed that in the case of a small cyst, especially one that is located in the tail of the pancreas, or a cyst that appears to be easily removable technically without too great a risk of injury to the surrounding vital structures, pancreatectomy is the best treatment whenever possible.

Simple drainage by means of a large rubber catheter, a cigarette drain, or marsupialization may be used in those cases unsuitable for excision. However, it is shown that there are many disadvantages of such management, such as the persistence of draining fistulas, the excoriation effect of pancreatic juice on the skin, and the tendency to recurrence.

The method of internal drainage by anastomosis of the cyst wall to the stomach, used in the case reported, will obviate the disagreeable features of external drainage and will insure adequate drainage. The care of the skin is reduced to a minimum, and frequent prolonged dressings are eliminated.

It has been shown roentgenologically at various time intervals following pancreatic cystogastrostomy that abnormalities of the stomach at the site of the anastomosis fail to exist and that eventually the cystic cavity atrophies and disappears.

Another case report of successful pancreatic cystogastrostomy is added to the literature.

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ROLE OF RADICAL SURGERY IN EXTENSIVE AND RECURRENT MALIGNANT LESIONS OF THE FACE AND SCALP

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THE ROLE of radical surgery in the treatment of cancer is well established. The literature contains many examples of the application of this principle in the therapy of malignant lesions considered inoperable only a few years ago. With the tremendous forward strides in anesthesia, fluid-balance, and antibiotic therapy, older patients are tolerating more and more radical procedures, designed to eradicate both the local and distant effects of malignant disease. The criteria of operability have widened, not only in regard to the size, extent, and location of the lesion, but also in regard to the associated physiological disabilities of the geriatric patient. These may be completely unrelated to his malignant disease, such as cardiovascular or renal insufficiency. Martin [8] quotes Dr. Jules Abels as saying, "There are no medical contraindications to cancer surgery."

Radical surgery, however, has been largely limited to those malignant growths arising in the abdominal, thoracic, and oral cavities. With the exception of the malignant melanoma, little emphasis has been placed on the surgical treatment of extensive and recurring malignant tumors of the face and scalp. Radical surgery is severely deforming, and, too often, the justifiable desire of the surgeon to prevent or minimize deformity leads to inadequate excision with inevitable recurrence. Temporizing with cancer to avert cosmetic deformity leads only to the loss of control over disease and patient.[1] If, however, postoperative deformity is an acceptable penalty for cure, radical surgery has a definite and important role in the treatment of these extensive and recurrent tumors of the face and scalp.

BASAL-CELL CARCINOMA

The commonest form of cancer of the skin of the face is the basal-cell carcinoma.* It is easily recognized in its early form and may be completely eradicated by either adequate local surgical excision or focal radiation therapy of about 5,000 r.[4] The five-year survival rate in most series of tumors less than a centimeter in diameter approaches 90 to 95%.† This tumor is regarded often as a minor

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* References 7, 9, 16, and 23.

† References 2, 4, and 7.

malignant growth because of its tendency to remain local and to spread by invasion of the surrounding tissues rather than by regional lymphatics or bloodstream with distant and disseminated metastases.

It is, however, this very property of local invasiveness, explained by Holztman [5] on the basis of cellular cohesion of the basal layer of the skin, which makes extensive or recurring basal-cell carcinoma one of the most difficult to treat. The insidiousness and persistency of the basal-cell tumor is its most disillusioning attribute. It may lie dormant for months, only to break out anew, and despite repeated courses of irradiation and repeated surgical excisions, this tumor can and does recur and may, in time, revert to the basosquamous-cell type with its attendant danger of widespread metastasis.‡

The surface manifestation of this carcinoma often represents only a small part of the actual local involvement. A possible multicentric origin of basal-cell carcinoma may perhaps explain, in part, this phenomenon of local extension which often defies what appears to be a complete surgical excision or an adequate area of irradiation. Like an iceberg, however, there is often extensive involvement beneath an innocent-appearing surface.

The recurring basal-cell lesion of the face and scalp lends itself admirably to radical surgical excision. Its chronic nature and rare metastatic spread make this tumor surgically accessible. Even the large fungating recurrences, with histories of 15 to 20 years, punctuated at intervals by inadequate attempts at control, may be successfully treated if the surgeon approaches the problem without fear of the inevitable cosmetic deformity. The treatment of these extensive and recurring carcinomata of the face and forehead will depend largely upon their location, size, and particularly the depth of local invasion. Either x-ray therapy, radium therapy,[2] or adequate surgical excision is sufficient in the earliest form of the disease, but once the tumor has recurred, radical surgical excision is the treatment of choice.

Excision of a wide margin of normal tissue in all directions is essential. These unpredictable tumors may spread far beneath a normal-appearing surface and may be multicentric in origin. If necessary, the bony structure of the face and skull, the nose, paranasal sinuses, and orbit should be sacrificed if there is any evidence of extension of the tumor into these structures. The gross determination of an adequate margin about an extensive tumor is virtually impossible; consequently, the adequacy of resection has been routinely tested during surgery by serial frozen sections. These sections are obtained around the entire margin and from the depths of the resected area and are repeated until there is no evidence of tumor remaining behind. An extensive carcinoma of the nose, which grossly appeared adequately excised, was found by frozen section to extend into the adjacent ethmoid sinuses (Fig. 1). Similarly, a carcinoma of the lower eyelid was found on serial frozen section to extend deeply into the underlying orbital fat and thereby necessitated total exenteration of the orbit before pathological evidence of an adequate resection could be obtained (Fig. 2).

Postoperatively, the final cosmetic reconstruction of the operative defect should be postponed, particularly when the nose, nasal sinuses, or orbital contents have been sacrificed. Reconstruction is routinely delayed until a prolonged period of

‡ References 6 and 24.

careful observation has shown that the danger of recurrence is virtually past. All large surgical defects of the face and forehead are left open until the patient is at least a year, and preferably 18 months, without evidence of recurrence (Fig. 3).

Large soft tissue defects, however, are routinely resurfaced with split-thickness grafts at the time of original operation to convert the defect into a closed wound, which still can be observed closely (Fig. 4). Any attempt to reconstruct such a defect with either a local, rotation, or distant pedicle flap is then delayed for a

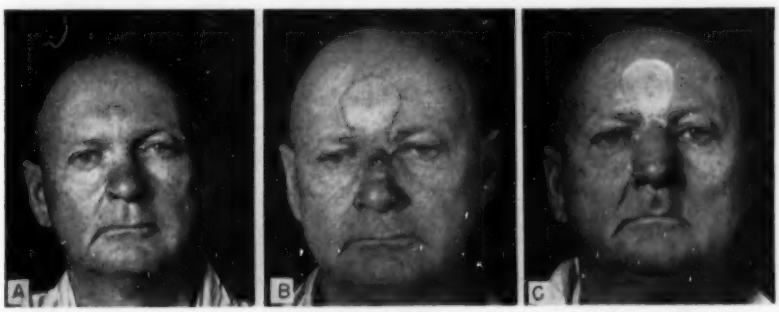

Fig 1.—*A*, extensive basal-cell carcinoma of the nose in a 64-year-old mute who has received 4,000 r of x-ray therapy and 1,500 mg. hours of radium over a 14-year period. *B*, 18 months following radical resection of nose and ethmoid sinus. *C*, eight months following reconstruction of the nasal dorsum with median forehead flap.

Fig. 2.—*A*, 67-year-old farmer who treated his own recurrent basal-cell carcinomata with iodine and carbolic acid for a period of 10 years. *B*, four months after radical surgery requiring exentration of orbit, when serial frozen section revealed invasion of the orbital fat. The soft tissue defect was converted to a closed wound with a split-thickness graft, and the open socket will be followed for 18 months before reconstruction is begun.

similar prolonged period. The immediate reconstruction of a radical surgical defect with a flap prevents adequate follow-up. Recurrent tumor may be completely hidden beneath such a flap, and by the time recurrence is evident on the surface the depth of invasion has precluded further definitive treatment.

If the surgical defect is severely deforming and adequate prosthetic restoration can be made, a dual purpose may be served (Fig. 5). The cosmetic deformity can be reduced to a minimum, and the operative defect will remain open to careful

periodic examination for an indefinite time. In many older patients with unrelated severe organic disease the prosthesis is of sufficient cosmetic camouflage to obviate the necessity of multistaged surgical reconstruction.

SQUAMOUS-CELL CARCINOMA

Squamous-cell carcinoma is the next commonest malignant lesion of the face and is difficult to treat even in the early stages because of its tendency to metas-

Fig. 3.—*A*, slowly growing basal-cell carcinoma of the forehead of seven years' duration in a 43-year-old man, which had received two courses of topical radium therapy without benefit. *B*, six months after radical resection of the forehead and exenteration of the right orbit. Orbital involvement was proved by frozen section at the time of operation. Reconstruction was deferred for 14 months. *C*, two and a half years without evidence of recurrence after reconstruction by abdominal tubed pedicle flap on a wrist carrier.

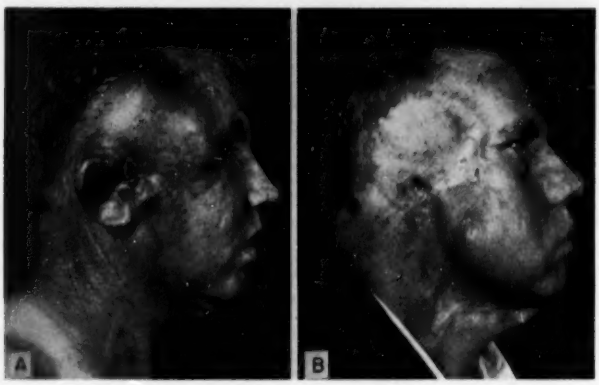

Fig. 4.—*A*, extensive squamous-cell carcinoma of right face and scalp of 18 months' duration which had received no previous therapy. *B*, 14 months following radical resection of ear, face, scalp, outer table of the skull, and right radical neck dissection to margins shown to be tumor-free by serial frozen sections without evidence of recurrence. Open wound was resurfaced one month later by split-thickness skin graft to convert the granulating area to a closed wound.

tasize. If the carcinomata of the oral cavity are excluded, it is not a common lesion and occurs primarily on the lower eyelids or lips and in conjunction with a disseminated skin reaction to actinic radiation.[8] This latter form, known as "sailor's skin," occurs almost exclusively in males with blue eyes and fair skin, whose occu-

pations demand prolonged exposure to the sun. Though deforming and difficult to erradicate, it is slowly progressive, slow to metastasize, and very amenable to radical excision and grafting (Fig. 6).

In the scalp, however, squamous-cell carcinoma is the commonest form of cancer. It occurs in cutaneous horns, sebaceous cysts,§ and other benign lesions; which are mechanically irritated by brushing or combing the hair, as well as in

Fig. 5.—*A*, 54-year-old farmer with a very rapidly growing mass on the left side of the nose of three months' duration, which showed no response to 2,000 r of x-ray. Biopsy revealed squamous-cell carcinoma. *B*, postoperative appearance 18 months after radical excision of nose, paranasal sinuses, and anterior wall of the left maxilla. *C*, nasal prosthesis made of Dicor-A S-79 Elastic Resin for anatomical restoration, Vernon-Benshoff Company, Pittsburgh, which allows careful postoperative follow-up with minimal cosmetic deformity.

Fig. 6.—*A*, "sailor's skin" in a 38-year-old farmer who gave a seven-year history of multiple recurrent crusted areas over the left cheek and side of the neck despite electrocautery and carbon dioxide snow therapy. *B*, 18 months without evidence of recurrence following radical resection of skin of the left face and neck with primary spilt-thickness skin-graft reconstruction.

burn and irradiation scars,‖ particularly those which have been allowed to heal secondarily with a thin, atrophic, epithelial covering. These tumors are usually bulky, ulcerate early, but are slow to metastasize. Radiation therapy, while of value in the early lesions of the face, is of little value and may be dangerous in the extensive or recurrent lesions or those carcinomata arising in scar. Pendergrass

§ References 25 and 27.

‖ References 10, 11, and 12.

reports on three patients with acute intracerebral damage, suppurative meningitis, and eventual death, following irradiation of an extensive carcinoma of the scalp.[26]

The treatment of the squamous-cell lesion of the face is entirely similar to that of basal-cell carcinoma, and radical surgery is reserved for the extensive and recurring lesions and those with metastases. The surgical approach to lesions of the scalp, particularly those occurring in old irradiation or burn scars, is more complex. In these tumors, adequate excision of the carcinoma is insufficient. The associated areas of unstable scar epithelium must also be completely removed before the resection can be considered complete. The adequacy of excision is routinely checked by serial frozen section. Often the extension of these tumors through the scalp requires resection of a large area of periosteum with attendant devitalization of the underlying cortical bone. If there is no evidence of invasion of the cortex, the outer table of the skull is then removed at the time of resection. This is resurfaced in a second stage with a split-thickness skin graft, as soon as the granulating surface is ready, converting the defect to a closed wound which

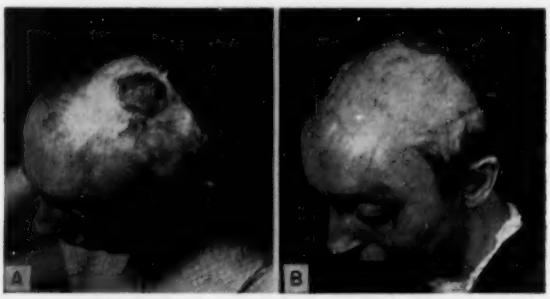

Fig. 7.—*A*, a 32-year-old woman with a Marjolin ulcer of the scalp of two years' duration, following a third-degree burn at 9 months of age, which was allowed to heal secondarily. *B*, postoperative appearance nine months after radical excision of tumor mass, entire area of unstable burn scar, and outer table of the skull, with reconstruction by split-thickness graft.

may be followed. The final cosmetic reconstruction is again delayed until a sufficient period has elapsed to reduce the possibility of recurrence to a minimum (Fig. 7).

If both tables of the skull are involved with carcinoma and the dura is exposed or invaded, the surgical approach is entirely different. In such tumors, where resection of a large area of skull and dura is necessary to obtain an adequate margin, the operative defect must be closed primarily by pedicled tissue, because any dural defect must be closed and sealed to prevent a cerebrospinal fluid leak, with attendent meningitis or cerebral fungus.

Many substitutes for the dura have been suggested, but the most satisfactory for large dural defects is either a free fascia lata graft or the pericranium of the adjacent scalp.[15] The dural defect, whether grafted by fascia lata or pericranium, must be covered by a pedicle flap with competent circulation at the time of resection for the free dural graft to survive.

In extensive carcinoma of the scalp with invasion of the dura, adjacent pedicle flaps are prepared by elevation and delay prior to radical resection, so as to insure

their circulatory competence at the time of definitive surgery. The involved dura, and if necessary the subjacent cortex, is then resected to margins proved tumor-free by serial frozen section. Fascia lata has been routinely used as a free graft to reconstitute the dural envelope, and this is, in turn, covered and nourished by the previously prepared adjacent pedicle flap. Thus it is possible to resect not only the skull but also the underlying dura and, if necessary, the involved cerebral cortex to eradicate the local spread of extensive cancer of the scalp and forehead (Fig. 8).

In the extensive squamous-cell lesions of the face and scalp the treatment of the metastasis is also a surgical function. If the carcinomata of the oral cavity are again excluded, metastatic spread is usually late in the course of the disease, and the presence of involved lymphatics does not necessarily preclude cure, even though the ultimate prognosis must remain guarded. The lymphatic drainage of the face is easily and completely interrupted by radical neck dissection on one or, if necessary, both sides,[3] and even though the nodes of the upper neck may be

Fig. 8.—*A*, 59-year-old woman with a 20-year history of recurring basal-cell carcinoma of left forehead, which has received 15 separate courses of radiation therapy and one attempt at surgical excision without benefit. X-rays showed total destruction of left supraorbital ridge and part of orbit. *B*, 10 months following radical resection of forehead, skull, orbit, paranasal sinuses, dura, and left frontal lobe. Primary reconstruction done by free fascia lata graft, covered by two adjacent rotation flaps. There is no evidence of recurrence.

involved division of the lymphatic pathways at the level of the clavicle may effectively block the spread of carcinoma to the vital structures within the thorax or abdomen. Indeed, in the squamous-cell as in basal-cell carcinoma the local invasion of the skull and vital centers of the head is more to be feared than the metastatic spread.

MALIGNANT MELANOMA

Malignant melanoma is the third commonest cancer of the face and scalp. From 23 to 30% of all malignant melanomas occur about the head and neck,[18] and these must be treated by radical surgery. This tumor is characterized by its innate malignancy. Local recurrence is frequent, and lymphatic or hematogenous spread to vital structures is early.[20] Melanoma is also entirely radioresistant.[21] The surgical principle proposed by Pack[19] of "in continuity" resection of skin and lymphatic drainage of malignant melanoma is generally accepted as the best

available method of treatment of this highly malignant disease, and even though the ultimate prognosis of any malignant melanoma is poor, the location and lymphatic spread of a lesion about the face and scalp lends itself well to treatment by radical surgery (Fig. 9).

PALLIATION

Beyond the scope of the curable malignant lesions, a final indication for radical surgery lies in palliation. All too often, patients with extensive lesions of the face and scalp show evidence of distant and disseminated metastases at the time of

Fig. 9.—*A*, and *B* melanosarcoma in a 30-year-old man with a year and a half history of a rapidly growing tumor in the left parotid region associated with a small mole. His only treatment was with "cancer paste." *C* and *D*, patient, now five and one-half years after radical resection "in continuity" of face and ear and left radical neck dissection, with no evidence of recurrence.

original examination and therefore must be considered incurable. Yet, if intractable pain is present, or a large fungating foul-smelling mass makes terminal existence miserable, palliative radical resection often brings marked relief and more than compensates for the deformity incurred. In these instances, cosmetic reconstruction, either surgical or prosthetic, should be carried out primarily, for the presence of distant metastatic involvement makes the careful and prolonged follow-up for local recurrence unnecessary.

SUMMARY

Radical surgery plays an important role in the treatment of extensive and recurrent malignant lesions of the face and scalp.

The acceptance of postoperative deformity is essential.

A tumor-free margin of resection can be determined by serial frozen sections at the time of operation.

Final cosmetic reconstruction of the surgical defect should be delayed until the possibility of recurrence is remote, except when resection of dural envelope demands pedicle-flap coverage for the nourishment of a free dural graft.

The "in continuity" resection of skin and lymphatics is the best available method of treatment for malignant melanoma of the face and scalp.

Surgical palliation of incurable cancers can, in carefully chosen cases, be valuable.

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RHABDOMYOSARCOMA OF THE CHEST WALL

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TWO HUNDRED twenty-two cases of malignant tumor of skeletal muscle origin have been reported in the literature.* Of these, only five were rhabdomyosarcoma of the chest wall, and nine were grouped as involving the abdomen, back, or chest wall. The patient reported on here represents an additional case of rhabdomyosarcoma of the thoracic wall.

C. F. C. (Boston VAH, Reg. No. 2747), a 65-year-old white male office worker, was admitted Oct. 6, 1952, with a chief complaint of a mass of the left thoracic back of five months' duration. Fleeting soreness first called his attention to the area. A mass appeared shortly afterward which had not been noted to change in size. There was some soreness of the area after prolonged sitting but no radiating pain or interference with motion. He had lost 8 lb. (3.6 kg.) in the five-month period.

The patient had had no serious illness, and the system review was entirely negative.

Physical examination was normal except for the back. There was a 12 cm. round firm, nontender mass over the 9th, 10th, and 11th ribs to the left of the midline posteriorly (Fig. 1). The mass appeared attached to the ribs and paraspinal muscles, moving with them on motion of the trunk. The skin was movable over it.

Significant laboratory findings were as follows: WBC 13,800, with 85% neutrophiles, 14% lymphocytes, and 1% eosinophiles. Hemoglobin, 11 gm. per 100 cc. Urine normal, concentrating to 1.022. NPN 43 mg. per 100 cc. Inorganic phosphorus 2.5 gm. Acid phosphatase 0.9 King Armstrong units. Alkaline phosphatase 3.5 Bodanski units. Total protein 7 gm., with 3.4 gm. albumin and 3.6 gm. globulin. Kahn negative. Calcium, 10.7 mg.

X-rays showed complete destruction of approximately 8 cm. of the vertebral end of the left ninth rib, with a large, well-defined, overlying soft tissue mass (Fig. 2). The lung fields were clear. X-rays of the skull and long bones were normal, as were an intravenous pyelogram, barium enema, and gastrointestinal series.

On Oct. 22, the mass was excised. Since the skin was not attached to the mass, none was removed, but a block of the muscles overlying and containing the mass, together with portions of four ribs (the 8th, 9th, 10th, and 11th) and the underlying pleura, was excised. Frozen section diagnosis was "probable sarcoma." The large defect of the bony thorax thus created was then bridged by detachment of the sixth and seventh ribs posteriorly. They were then brought down and attached to the transverse processes and body of the lower vertebra by threading heavy silk through drill holes in the ribs, transverse processes, and vertebra. Notching

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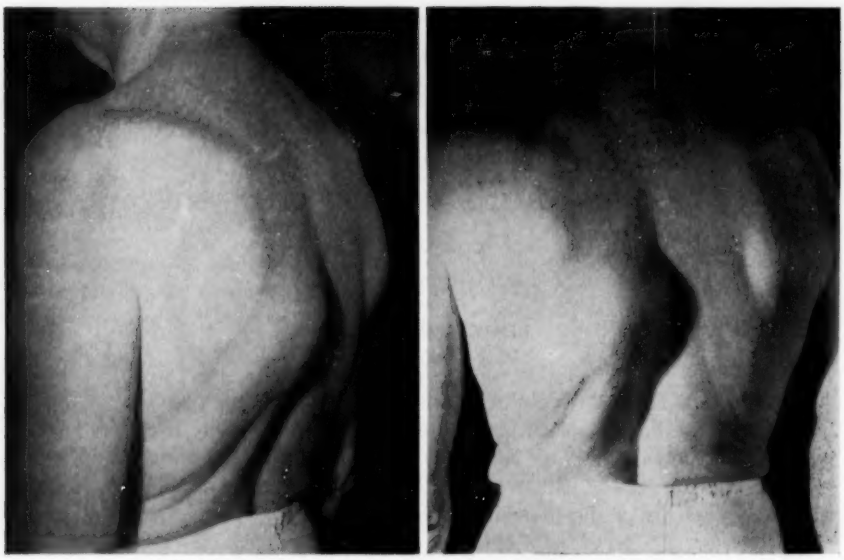

Fig. 1.—Preoperative photograph showing chest wall mass.

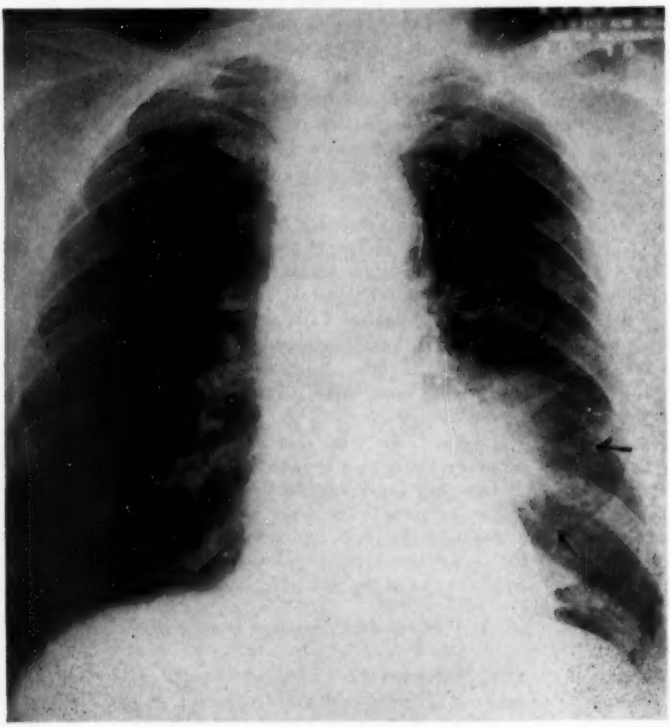

Fig. 2.—Arrows point to soft tissue mass in preoperative x-ray. Rib destruction is difficult to make out in this view.

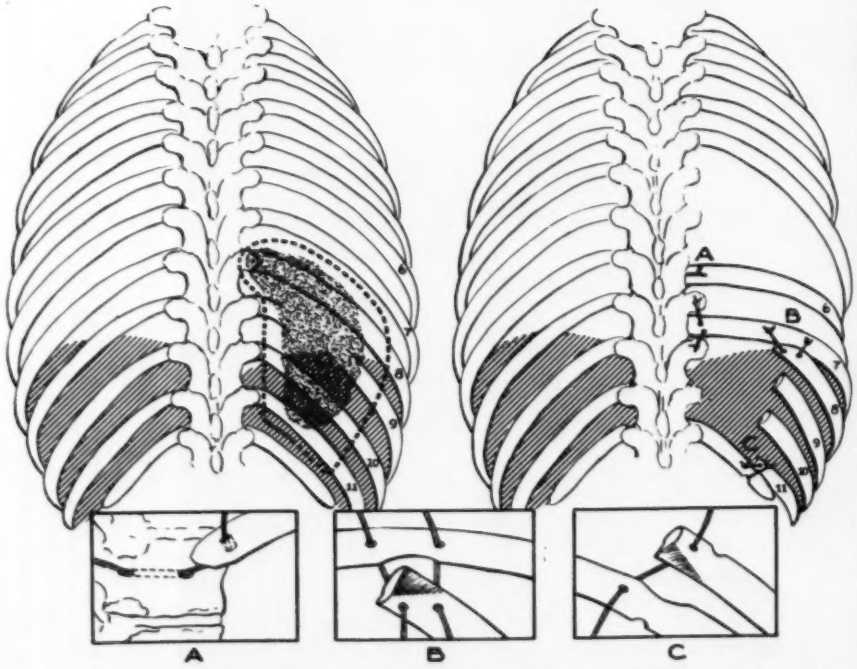

Fig. 3.—Diagram on left shows defect created by tumor excision. Method of repair is shown on the right. Details of rib fixation are illustrated by inserts *A*, *B*, and *C*. Parietal pluera, periosteum, and intercostal muscles were mobilized up to the second rib and brought down to close the pleural defect.

Fig. 4.—Gross specimen.

of the ribs and vertebrae with formation of mortise and tenon joints helped to obtain a stable chest wall (Fig. 3). The postoperative period was uneventful. The chest wall closure provided adequate support, and there was no buldging or paradoxical motion on coughing or straining.

One year after the operation the patient was entirely well. His weight was steady, and there was no evidence of local recurrence or distant metastasis by physical examination or chest x-ray.

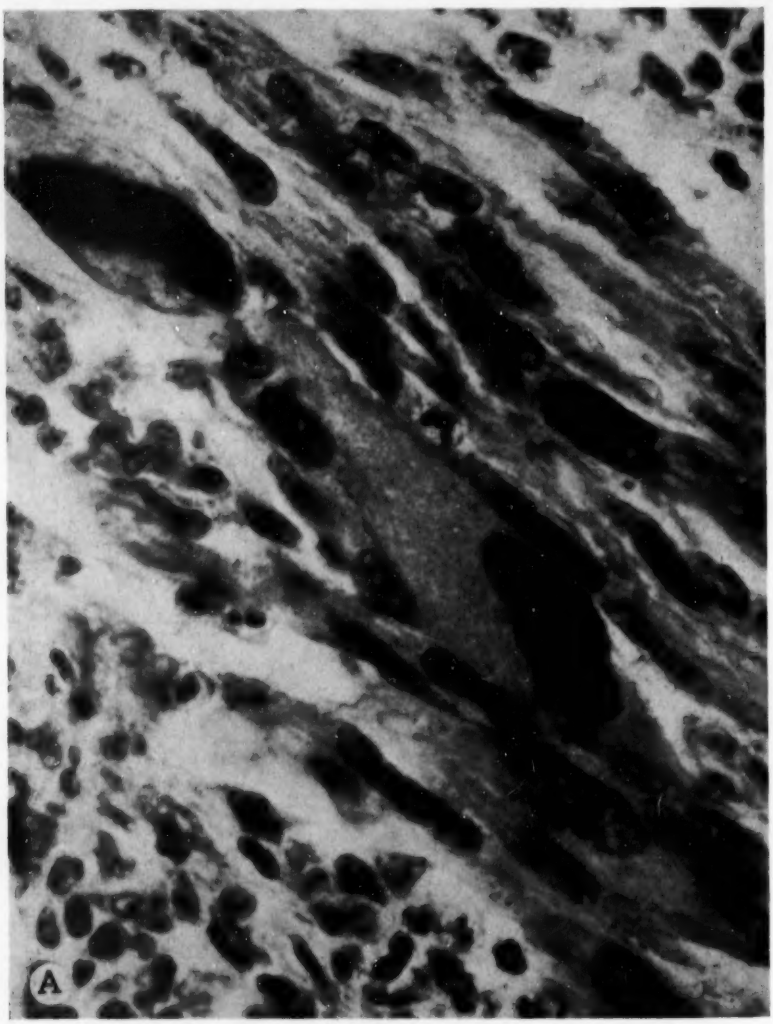

Fig. 5.—Photomicrographs show marked cellularity with cytoplasm occasionally drawn out into ribbon-like structures.

The specimen was 9 by 14 by 6 cm. and contained 14 cm. segments of four ribs (Fig. 4). There was a semiencapsulated mass within it extending to, but not through, the pleura and covered externally by skeletal muscle. It was 9 cm. in largest diameter. It was gray-white with few lobulations and a thin membrane surrounding it. The mass had invaded and destroyed a rib and some adjacent intercostal muscles.

Microscopically, there was marked cellularity. The cells had abundant acidophilic cystoplasm occasionally drawn out into ribbon-like structures. The cystoplasm was occasionally granular with very indistinct striations visible. There was active invasion of the fibrous psuedocapsule (Fig. 5*A* and *B*). Diagnosis: Rhabdomyosarcoma (Dr. Robert Fienberg).

Pack and Eberhart [2] included nine cases of rhabdomyoma of the chest, abdomen, and back in their series of 100 skeletal muscle rhabdomyosarcomas. They do not list the chest-wall cases separately. In Stout's [1] 121 cases of rhabdomyosarcomas, there were four involving the chest wall. A single case was reported by Beardsley.[3]

The treatment of rhabdomyosarcoma by surgery, by radiation, or both has produced very few long-term survivals.

Stout reported one case from Presbyterian Hospital of a 35-year-old man who died eight months after biopsy and x-ray therapy. He cites three cases from the literature. In these three cases one of the patients was known to have residual tumor; one patient was dead 38 months after his first operation, and the third patient was alive six years after excision combined with x-ray. The patient reported on by Beardsley died two years postoperatively with recurrent tumor. Pack reports one five-year survival in four cases of rhabdomyoma of the chest, abdominal wall, and back. In the other five cases in this group the patients were classed as non-determinant, and their status was not detailed. This represents two five-year survivals in a group of nine cases. In contrast, there were only 4 five-year survivals among the 108 patients treated in Stout's series of all muscle sarcomas and 22 among the 65 cases which Pack called determinant in his series of 100.

SUMMARY

A case of rhabdomyosarcoma of the chest wall is presented. Treatment was by radical excision, and the bony thoracic defect was bridged by dividing three ribs posteriorly and reattaching them at a lower level.

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Special Review Article

PATHOGENESIS OF ACUTE RENAL INSUFFICIENCY SEEN IN SURGICAL PATIENTS

Experimental Evaluation of Certain Factors: A Résumé

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SEVERE oliguria or anuria in surgical patients is of grave significance, for it indicates a serious illness and, if it is the consequence of organic renal damage, severe disturbance to the most important machinery for the maintenance of fluid and electrolyte balance in the body. We have obtained more information concerning the pathogenic factors in the etiology of acute renal failure as encountered in surgical patients by experimentally evaluating individually those factors considered most likely to be involved. The purpose of this communication is to present the conclusions and concepts derived from these studies and to correlate them with the reports of other investigators.

PROLONGED HYPOTENSION AND SHOCK

It is well recognized that severe hypotension will reduce renal function and urine flow, inasmuch as renal function is so intimately dependent on blood flow, pressure, and other hemodynamic factors. However, renal function usually recovers rapidly on restoration of a normal blood pressure. But if hypotension persists or prolonged shock exists, significant damage to the kidneys may occur.* Other tissues, especially the liver, also sustain injury, but the kidneys appear to be especially susceptible and the clinical consequences of severe renal damage are more striking than those of damage to other organs.

The tissue damage occurring as a result of prolonged hypotension or shock appears to be secondary to ischemia and probably the consequences of severe vasoconstriction associated with a markedly reduced blood flow.† Inasmuch as the degree of vasoconstriction varies considerably and is not necessarily directly correlated with the severity of hypotension, marked variations in the severity and extent of the renal lesions occur. In general, however, the hypotension must be prolonged for hours before renal lesions occur. It is actually infrequent that fatal renal insuffi-

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* References 1 and 2.

† References 1, and 3 to 9.

ciency results from prolonged hypotension. In experiments on dogs, a mean arterial blood pressure of 70 mm. of mercury, produced by controlled bleeding, had to be maintained at least six hours before significant histologic renal lesions occurred.[1] Even though the blood pressure was maintained at this level for 24 hours, the renal lesions were not always sufficiently extensive to produce clinical evidence of reduced renal function. Nevertheless, it is to be remembered that these experiments and clinical data indicate that prolonged hypotension, with the associated renal vasoconstriction, can cause renal damage sufficient to result in acute renal insufficiency.

Clinically, polyuria may occur in some instances in the face of severe renal damage and rising blood urea or nonprotein nitrogen levels. This is understandable in the light of the fact that the resection of approximately two-thirds of normal kidney substance is followed by polyuria and retention of nitrogenous waste products.‡ Since the lesions following prolonged hypotension most frequently appear to be infarcts of varying size, large areas of relatively normal renal tissue may persist so that polyuria instead of oliguria may occur. A consistent change in the urine associated with renal ischemia produced by any of many methods is the occurrence of gross or microscopic hematuria. The hematuria may be only transient or may last several days.

The renal lesions of shock are not limited to one or several segments of the renal tubules. Instead the lesions involve areas of the kidneys of varying size and thus involve the various segments of the tubules which may be in this involved portion of renal tissue. These lesions are most frequently located in the cortex. In our experiments, the severity and extent of the renal damage morphologically were unpredictable and varied from focal areas of degenerative changes in the tubules to bilateral cortex necrosis. Casts in the tubules may be present and are hyaline casts or debris from degenerating cells or protein casts. Pigment casts are rare. These views, based on our experimental studies, agree with those of Oliver and co-workers,[12] Sheehan and Moore,[13] Bell,[14] Moon,§ Herbut,[17] Allen,[18] and Lynch and Large,[19] who have studied the kidneys of man following shock. Mukherjee [20] also reached similar conclusions after experimental studies. In our studies, there was no evidence that the renal damage could be attributed to either the influence of the renal nerves or any constant pattern of deviation of blood through the kidneys.

THE ROLE OF NERVOUS INFLUENCES

For years, the renal nerves have received considerable attention as being involved etiologically in what has been termed "reflex anuria." More recently, the renal nerves have been again the subject for additional studies following the reports of Trueta and co-workers.[21] These investigators reported that stimulation of the renal nerves or impulses carried by the renal nerves, reflexly produced as by sciatic nerve stimulation, resulted in a deviation in the pathway of the intrarenal flow of blood so that the blood would flow only through the juxtamedullary glomeruli and medulla of the kidney, thus bypassing most of the cortex and rendering the cortex ischemic. It was postulated that this might be responsible for the production of renal damage and insufficiency in the crush syndrome, shock, "bilateral cortical necrosis," and other conditions.

‡ References 10 and 11.

§ References 15 and 16.

We have approached this problem experimentally by studying the effects of prolonged renal nerve stimulation.|| Although impulses mediated through the renal nerves by direct or reflex stimulation caused marked renal vasoconstriction and a marked decrease in renal function, the vasoconstriction could not be maintained at a sufficiently intense level over a sufficient period of time to produce clinically significant renal damage. It must be remembered that the renal artery of the remaining kidney in the dog, following removal of the other kidney, must be occluded four hours or more before fatal renal insufficiency occurs.¶ Deviations in the distribution of blood through the kidney during renal nerve stimulation did not persist long enough in our study to be of clinical significance. The conclusions are in agreement with the findings reported by many investigators during the past several years.#

Prolonged electric stimulation of the renal nerves may produce anuria or oliguria as a result of severe renal vasoconstriction and probably also the liberation of the antidiuretic principle.[28] However, this anuria or oliguria could not be maintained for more than 70 minutes in our experiments. Therefore, it is most probable that so-called reflex anuria, if such does occur, is not due to impulses mediated by the renal nerves.

The available evidence indicates that the renal nerves are not responsible for the production of acute renal insufficiency.

PIGMENT EXCRETION

Acute renal insufficiency as seen clinically is frequently associated with excretion of pigment, that is, myoglobin or hemoglobin. The source of the pigment is from muscles subjected to trauma and ischemia (myoglobin) or transfusions with incompatible blood (hemoglobin).*

It is common experience that in normal animals hemoglobinemia or myoglobinemia, although not innocuous, does not cause clinically significant renal damage.† The pigment is excreted by the kidneys and may cause polyuria. Likewise, clinical syndromes in man in which hemoglobinemia alone occurs do not necessarily result in significant renal damage.‡ Hemoglobinuric or myoglobinuric nephrosis can be produced experimentally, however, by a combination of hemoglobinuria or myoglobinuria and conditions causing renal ischemia or renal tubular injury.§ Severe oliguria and a high plasma concentration of hemoglobin or myoglobin favor the formation of pigment casts and the production of acute renal insufficiency. Thus, the combination of shock or severe dehydration with hemoglobinemia has been found to result in hemoglobinuric nephrosis. However, even under such severe conditions the renal lesions frequently are not fatal.[55]

In agreement with reports of other investigators, we have been able to produce hemoglobinuric nephrosis experimentally in the following ways:

1. Administration of homologous hemolyzed erythrocytes to animals after severe water restriction.

|| References 22 and 23.
¶ References 24 and 25.
# References 26 to 34.
* References 35 and 36.
† References 1 and 37 to 41.
‡ References 18 and 42 to 46.
§ References 38, 39, 41, and 47 to 54.

2. Administration of homologous hemolyzed erythrocytes combined with severe renal ischemia produced by constricting the renal artery. Others have accomplished essentially the same conditions by combining homologous hemoglobinemia with shock.‖

3. Administration of homologous hemolyzed erythrocytes to animals following prolonged severe restriction of salt.

4. Intravenous injections of heterologous hemolyzed erythrocytes, that is, injection of canine-hemolyzed erythrocytes into rats. The animals evidenced shock for a period of time after these injections. Rather [56] obtained similar results by the intraperitoneal injection of purified human hemoglobin into rats.

The kidneys of dogs showing changes due to shock or prolonged hypotension can usually be distinguished pathologically from those of hemoglobinuric or myoglobinuric nephrosis. Grossly, the kidneys of hemoglobinuric nephrosis, one of the pigment nephroses, usually show black areas on their surfaces and on their cut surfaces, especially in the juxtamedullary and medullary regions, due to the presence of numerous pigment casts concentrated in these regions. Grossly, the kidneys in shock may show several patterns including (1) congested medullas with pale cortices (although the cortices are occasionally congested too), (2) areas of pale infarcts and occasionally hemorrhagic infarcts of varying size in the cortex, and (3) relatively normal gross appearance.

The predominant feature of hemoglobinuric nephrosis most often is the presence of pigment casts, these casts being absent or few in shock kidneys. In hemoglobinuric nephrosis, the degenerative changes can be found in all segments of the nephron, but inasmuch as pigment casts are usually found in the ascending limb of the loop of Henle, the distal convoluted tubule, and the collecting tubule, the greatest damage appears to be in these segments. In shock kidneys the degenerative changes are not limited to any definite segment of the nephron, although the proximal convoluted tubule may be the site of the greatest injury. In general, all tubules within an area rendered ischemic show degenerative changes irrespective of the segment of the nephron.

It is likely that the crush syndrome is a result of a combination of factors, that is, myoglobinemia plus shock or other factors causing renal ischemia. It is thus essentially myoglobinuric nephrosis. The kidneys of the crush syndrome often show pathologic features of kidneys subjected to prolonged hypotension or shock as well as the changes associated with the presence of pigment casts. Also the livers in these cases show pathologic features which are usually attributed to shock or hepatic ischemia.¶

The exact causal relationship between tubular obstruction by casts and degenerative tubular changes in pigment nephroses has not been clearly elucidated. Opinion as to the relative importance of these two factors in causing acute renal insufficiency also varies. Even in the presence of extensive renal tubular damage, the pigment casts may be few.# According to some investigators, the pigment casts (methemo-

‖ References 39 and 45.

¶ References 1, 57, and 58

References 59 and 60.

globin) are responsible for the degenerative changes in tubular cells.* However, our experimental studies and the reports of other investigators indicate that some degree of renal tubular damage usually is associated with and probably precedes the formation of pigment casts.† In our studies pigment casts were generally found only in areas of tubular degeneration even though these areas of degeneration were small. In many instances the areas of tubular damage and cast formation appeared as cortical infarcts containing pigment casts, with the remaining renal parenchyma devoid of pigment casts and essentially normal in histologic appearance. Areas of tubular degeneration were large sometimes, yet few casts present were found only in locations of tubular damage. Furthermore, we observed that in control animals, subjected to the same conditions as test animals except for hemoglobinemia, areas of degenerative changes in tubular cells were present similar to those in the test animals except for the absence of pigment casts. In our opinion these degenerative changes are attributable to ischemia. Thus, conditions other than hemoglobinemia were responsible for the renal tubular changes in these experiments in which hemoglobinuric nephrosis was produced. Nevertheless, in some instances the pigment casts did incite an inflammatory reaction and may have exaggerated tubular damage. Also, dilatation of tubules above the casts occurred in some instances. Therefore, it seems to us that renal tubular damage probably precedes the formation of pigment casts in the tubules, but that the casts in turn add to the parenchymal damage and obstruct the tubules. Consequently, both tubular damage and pigment casts contribute to the interference with renal function in myoglobinuric and hemoglobinuric nephroses.

FLUID AND ELECTROLYTE DISTURBANCES

Severe depletion of water and electrolytes is associated with oliguria. However, oliguria is more characteristic of pure water deprivation than of pure electrolyte depletion. Under clinical conditions depletion of both water and electrolytes is usually present. The specific gravity of the urine is usually high. It is important to be able to determine whether the oliguria and retention of substances normally excreted by the kidneys are a manifestation of compensatory mechanisms of the kidneys to conserve water and electrolytes in the presence of dehydration or whether renal damage and acute renal insufficiency are actually present. This is a difficult task in the presence of complex and poorly understood fluid and electrolyte disturbances. The specific gravity of the urine serves as a useful and simple guide for this, usually being high when renal function is satisfactory and is compensating for dehydration, but being in the vicinity of 1.010 when acute renal insufficiency obtains.

Evidence available at present indicates that pure water depletion does not cause significant renal damage until shock or hypotension ensues.‡ Adolph [65] reached this conclusion also in studies of water depletion in man in the desert.

There is evidence indicating that significant renal damage can result from electrolyte depletion if sufficiently severe and prolonged. There are clinical reports of severe and fatal renal insufficiency presumably associated with alkalosis and salt

* References 49, 56, and 59.

† References 41, 54, 61, and 62.

‡ References 63 and 64.

depletion, including potassium depletion.§ Studies of electrolyte restriction in animals also have disclosed the presence of renal lesions attributed to electrolyte depletion.‖

We have carried out experiments in which some rats were subjected to acute severe water restriction while other rats were placed on water and a diet free of inorganic salts for up to four to five weeks.¶ In rats in which the effects on the kidneys of severely restricted intake of water alone were studied, small focal areas of vacuolar degeneration of tubular cells were present frequently but not consistently. The dehydration in these animals had to be severe before such lesions were noted. In other experiments in which the effect on the kidneys of rats of prolonged intake of water and food free of inorganic salts was studied, tubular degeneration varying in severity and extent was frequently observed. The lesions in this latter investigation were nearly always present and were considerably more severe than those seen after severe water depletion alone. Tubular casts were not a significant feature in the kidneys of these animals.

The pathogenesis of the renal lesions in dehydration, especially electrolyte depletion, is uncertain. The microscopic features of the lesions, however, could not be differentiated from the vacuolar degeneration and tubular necrosis we have observed in renal tubules resulting from ischemia produced by temporary occlusion of the renal artery or severe acute hemorrhage.# The lesions appeared to be small infarcts or areas subjected to temporary ischemia.

That the renal lesions occurring in severe dehydration, especially in severe electrolyte depletion, are secondary to renal ischemia is supported by experimental evidence reported by other investigators studying the effects of water and salt depletion. A number of studies have emphasized that in pure salt depletion plasma volume is decreased and can lead to peripheral circulatory failure.* Other investigators have also obtained evidence of renal circulatory deficiency in severe electrolyte depletion.† These findings are in contrast to pure water depletion, in which plasma volume and the blood pressure are maintained until late.‡ However, the exact pathogenesis of renal insufficiency occurring in association with severe electrolyte depletion and alkalosis is poorly understood. It is unknown whether depletion of one specific substance or whether changes in the pH might play a major role in the interference with renal function.

Thus, it is likely that severe water depletion and especially severe electrolyte depletion if prolonged over several days can cause degenerative lesions in the kidneys, the lesions probably being the result of renal ischemia. This can result in interference with renal function which is clinically significant and severe.

§ References 66 to 73.

‖ References 74 to 77.

¶ Reference 78 and unpublished data.

References 1 and 2.

* References 64 and 79 to 81.

† References 82 and 83.

‡ References 80, 84, and 85.

COMBINATION OF FACTORS

In patients as seen clinically it is obvious that in certain instances a combination of the foregoing factors is present, causing renal damage. Thus in patients with severe burns, shock or prolonged hypotension may be associated with or followed by severe electrolyte and water depletion. All of these factors would have deleterious effects on the kidneys.

A word of caution is warranted, however, against attributing oliguria to organic renal damage in all severely and acutely ill patients. In many such cases the oliguria and retention of products normally excreted by the kidneys are the consequence of a mild or moderate degree of hypotension and renal vasoconstriction associated with severe fluid and electrolyte disturbances occurring acutely. Significant pathologic changes in renal architecture are usually absent unless these conditions persist over a period of days. The function of all tissues and organs is diminished in such a situation, the reduced renal function being especially noticeable since oliguria is so obvious.

COMMENT

The foregoing factors and conditions, with the exception of direct or reflex renal nerve stimulation, appear to be frequent and important entities in the pathogenesis of acute renal insufficiency as seen in surgical patients. Of course, other factors such as preexisting renal damage are important in some cases.

One variety of renal insufficiency associated with jaundice might be included in the group of pigment nephropathies. If severe dehydration with salt depletion or renal ischemia produced by other mechanisms is present in association with jaundice, bile casts may form in the renal tubules and the kidneys develop the same features as hemoglobinuric nephrosis, except that the casts are bile casts and not hemoglobin or hemoglobin derivatives.§

It is to be remembered that actually the renal reserve is tremendous. Not only is the functional reserve of existing renal parenchyma great, but its capacity to regenerate rapidly is also great. Apparently before fatal acute renal insufficiency occurs, nearly all renal tissue must be rendered functionless. Thus, experimental conditions must be severe before a marked degree of renal insufficiency occurs. More than three-fourths of the normal renal tissue must be removed before death from renal failure occurs in dogs.|| Also, the renal artery of the remaining kidney in the dog, following removal of the other kidney, must be occluded three to four hours or more before fatal renal insufficiency occurs.¶ This explains the infrequency of severe persistent renal dysfunction or fatal renal failure following recovery from shock and other deleterious conditions. Muirhead [90] has emphasized that with conservative treatment hemolytic transfusion reactions are often not fatal. However, the conditions discussed herein can precipitate acute renal failure. It is obvious, therefore, that it is important to maintain adequate blood volume and electrolyte and fluid balance, especially in the presence of hemoglobinemia, myoglobinemia, and jaundice, to prevent renal damage.

§ References 2 and 86.

|| References 87 to 89.

¶ References 24 and 25.

CONCLUSIONS

1. Acute renal insufficiency as seen in surgical patients can arise from shock or prolonged hypotension, from pigment (hemoglobin, myoglobin) excretion under conditions of renal ischemia, and from severe, prolonged electrolyte and water depletion. Renal ischemia, due to renal vasoconstriction in association with reduced blood pressure and renal blood flow, plays a major role in the pathogenesis of the acute renal insufficiency occurring in these conditions.

2. The renal nerves do not appear to have a significant role in the pathogenesis of acute renal insufficiency.

3. In acute renal insufficiency associated with pigment excretion, blockage of tubules and exaggerated tubular damage appear to increase the severity of renal insufficiency.

4. The foregoing conditions must be severe before significant renal damage is demonstrable in previously normal kidneys. The reserve of renal parenchyma is great.

5. The maintenance of blood pressure, blood volume, and fluid and electrolyte balance in the prevention of acute renal insufficiency is essential.

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Scientific Exhibits

NEWER CONCEPTS CONCERNING THE COMMON BILE DUCT

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THE COMMON bile duct is a conduit serving to transport bile from the liver to the duodenum. This pipeline includes a "surge chamber" (represented by the gall bladder) permitting both storage and availability. The duct also has a "nozzle" at its termination, which increases the flow of bile to jet-stream velocity. These concepts conform to hydraulic principles.

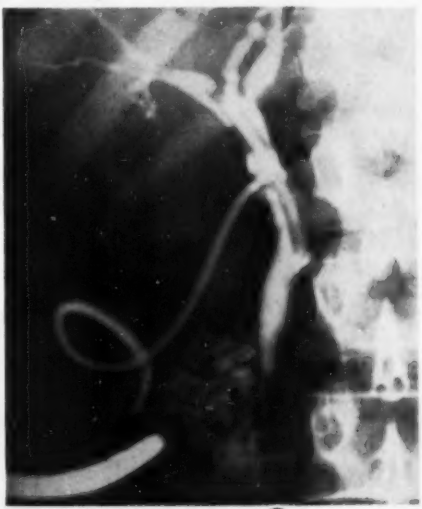

Fig. 1.—Postoperative cholangiogram illustrating normal pattern, contour, and relationships of the common bile duct.

The common bile duct has a constantly curving course. Its termination at the papilla of Vater is like a funnel in that the diameter of the lumen decreases rapidly.

Fig. 2.—Artist's drawing of the gross external appearance of the distal end of the common bile duct and pancreatic ducts, including the transduodenal "papilla."

The external appearance of the terminal (transduodenal) segment of the common bile duct is that of an expanded bulb. This enlargement occurs where the pancreatic duct appears to join the termination of the common bile duct. This bulbous character, for many years, led to a belief that a "space" was formed by the confluence of the pancreatic and common bile ducts.

From the Albert Einstein Medical Center, and The Medico-Chirurgical College, Graduate School of Medicine, University of Pennsylvania.

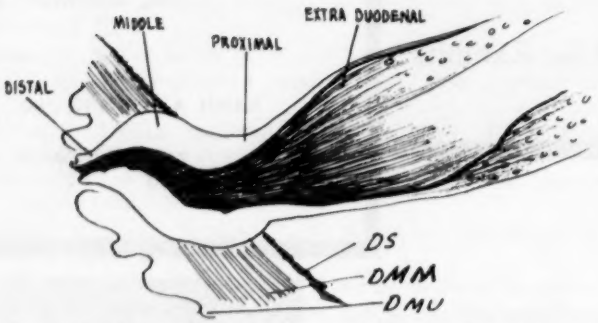

Fig. 3.—Artist's drawing of hemisection of papilla of Vater through the termination of the common bile duct.

When the enlarged segment is bisected it is found that it is a mass of sphincter (of Oddi) muscle. The diameter of the common bile duct lumen is very narrow. There is, then, no space (ampulla) but actually a mass (papilla) present at the transduodenal termination of the common bile duct.

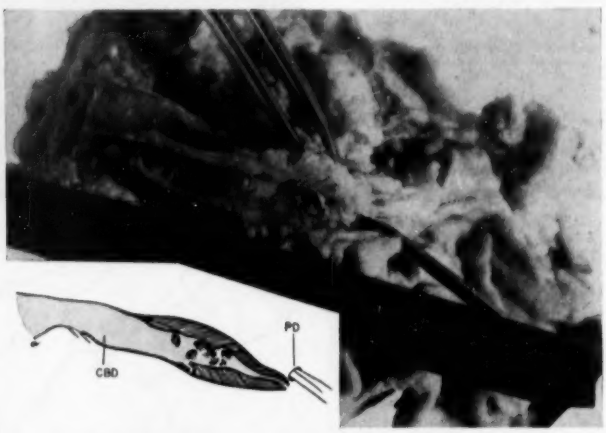

Fig. 4.—Photograph of lumen of common bile duct demonstrating the difference between extraduodenal and transduodenal (transpapillary) segments. Valvules are illustrated. Insert is artist's drawing of the photograph.

There are other differences between the extraduodenal and transduodenal (transpapillary) common bile duct. The extraduodenal duct is translucent, thin-walled (0.5 to 1.5 mm.), and flexible and contains three to four gland orifices per square centimeter. The papillary portion of the duct is dull, thick (0.3 to 1.9 cm.), and rigid and has numerous folds and mucosal reduplications acting like valvules.

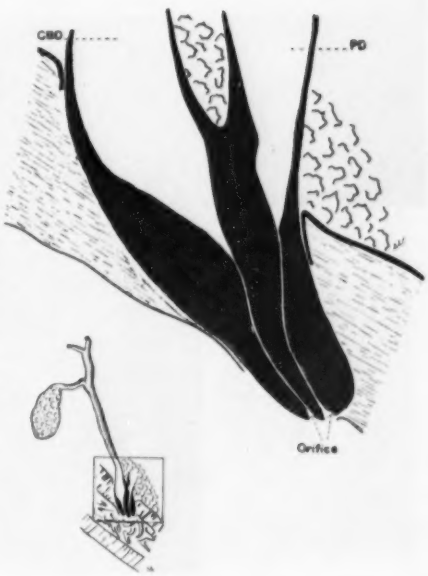

Fig. 5.—Artist's drawing of the course of the common bile and pancreatic ducts through the papilla of Vater.

The pancreatic and common bile ducts generally maintain their identity through the duodenal wall. Careful examination of intact cleared specimens after filling the ducts with opaque dyes demonstrates that in 80% of specimens the duct terminations are absolutely separated or there is a shallow common channel for 1 or 2 mm. In 14% of cases the common channel for pancreatic and common bile ducts is in the distal one-third of the papilla. In only 6% does the common channel for the ducts traverse more than half of the papilla.

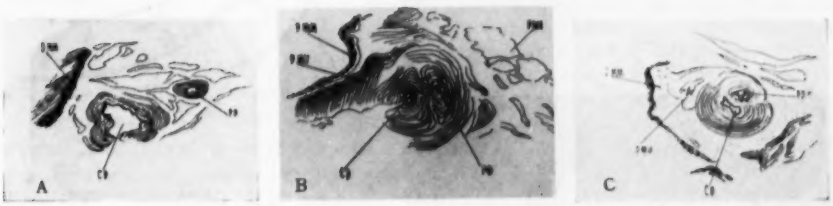

Fig. 6.—Artist's drawing of cross section studies through the (A) proximal, (B) medial, and (C) distal thirds of the papilla. The illustrations indicate the disposition of the sphincters surrounding the common bile and pancreatic ducts.

Consideration of the disposition and character of the papillary sphincter indicates that the presence of interductal reflux depends upon the existence of a common channel for the bile and pancreatic ducts for a distance greater than half the length of the papilla. Such conditions exist in less than 20% of specimens.

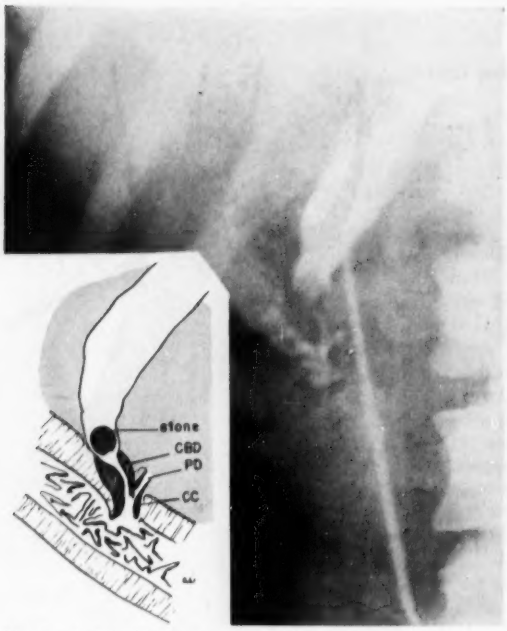

Fig. 8.—Artist's diagram of routes which a calculus may take.

Because of the mass of tissue present at the papilla, a stone within the common bile duct propelled by increasing intracholedochal pressure seeks areas of least resistance. These may be toward the pancreas and its duct or the duodenal wall. Frequently an abnormal interductal reflux is established through such traumatic or inflammatory choledochal-pancreatic fistulae. Pancreatitis is present in these cases.

Fig. 7.—Operative cholangiogram indicating usual location of impacted stone at the terminal segments of the extraduodenal common bile duct. Interductal reflux is present much distal to the site of the stone impaction. Insert is artist's diagram of this cholangiogram.

The percentage of interductal reflux (20%) has been confirmed by studies of postoperative cholangiograms. It is important to relate the site of normal interductal reflux to the site of stone impaction. Usually the calculus is lodged at the distal end of the extraduodenal common bile duct. It is unable to enter the duodenum through the normal common bile duct unless the stone is less than 0.3 cm. in diameter.

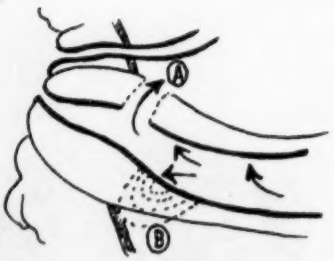

Fig. 9.—Postoperative cholangiogram.

Flow of bile through the papilla can occur at pressures from 9.0 to 23.0 cm. of bile; sphincter resistance normally is 12.0 to 15.0 cm. of bile. These are altered by abnormalities at the termination of the extraduodenal common bile duct and within the papilla. The papilla is from 8.0 to 12.0 cm. from the pylorus. It is elevated or on a level with duodenal mucosa in about 75% of persons. It is 0.3 to 1.9 cm. wide and 0.7 to 1.9 cm. long. While the diameter of the normal extraduodenal common bile duct is 0.7 cm., the diameter of the orifice through the papilla is 0.1 cm.

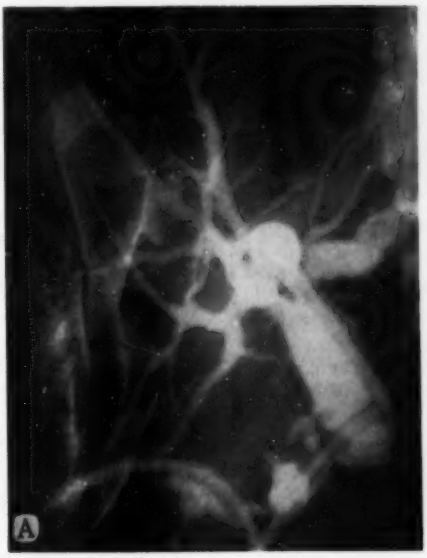

Fig. 10.—A, postoperative cholangiogram in patient with stricture at the terminal segment of the extraduodenal common bile duct. B, postoperative cholangiogram in patient with spasm at the termination of the common bile duct.

Abnormalities of the papilla are reflected by changes in the extraduodenal common bile duct. The most common change is that of dilatation to the intrahepatic ducts, the common hepatic duct, and the common bile duct. The common bile duct is abnormal when greater than 1 cm. in diameter. This can be seen in patients with stricture (*A*), spasm (*B*), or tumor.

COMMENT

The significance of the facts presented in this exhibit rests primarily in the descriptions of normal structure and function. Based upon this knowledge, the decisions made by the gastroenterologist, radiologist, and surgeon are accurate. Residual calculi could be more frequently suspected, tumor at the papilla more easily identified, and pain with dysfunction more readily relieved.

In addition, stricture may be differentiated from spasm, stone from tumor, and normal differentiated from abnormal interductal reflux.

Case Reports

CARDIAC ARREST DURING MITRAL COMMISSUROTOMY

Complete Recovery After Twenty-Four Minutes

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CARDIAC arrest can no longer be considered a rare phenomenon. With the tremendous increase in intrathoracic and cardiac surgery during recent years, attention has necessarily been focused on cardiac standstill during surgical operations, its causes and treatment. Rather general agreement exists that the principal underlying cause for this condition is probably on the basis of cerebral and myocardial hypoxia. It is felt that certain anesthetic agents, as for example cyclopropane, may result in cardiac arrest especially in the case of an already irritable or damaged myocardium. Excessive handling of the pulmonary hilus, the great vessels within the chest, and the heart itself may also contribute to this catastrophic occurrence through the so-called vagovagal reflex.

The recognition of cardiac standstill during the course of a surgical procedure demands immediate attention. The operative procedure must, of course, be discontinued, and all efforts on the part of both the surgeon and anesthesiologist directed toward restoring the normal cardiac rhythm. In the great majority of instances, the heart beat can be restored with regular manual massage if this is instituted sufficiently early and properly carried out, and the lungs are artificially expanded for the transport of oxygen to the brain and myocardium. Spontaneous heart-beat will usually be resumed within three to seven minutes. Ventricular fibrillation will occur in certain instances and may require the use of a defibrillator to restore regular rhythm.

The purpose of this communication is to cite an instance of cardiac arrest which persisted for 24 minutes during the course of surgery being performed for mitral stenosis. Spontaneous rhythm was restored following manual massage during this period of time. Despite the excessive time interval which elapsed, there was no evidence of cerebral damage in this instance, probably attributable to the fact that massage was immediately instituted as soon as it became evident that cardiac arrest had occurred. With an open chest, cessation of heart beat is immediately apparent and corrective measures can rapidly be instituted. In the case of abdominal or other types of surgery, however, cardiac arrest may intervene without the knowledge of the surgeon. By the time the anesthesiologist has discovered the fact that he cannot detect a peripheral pulse and that cardiac action has stopped and the surgeon takes steps to expose the heart either through the diaphragm or through a rapid thoracotomy incision, a period of three to five minutes or more has usually elapsed,

which may prove to be too long an interval to restore normal beat. If cardiac action is restored in such a situation, there is considerable likelihood of resulting cerebral damage.

REPORT OF A CASE

Mrs. R. R., a 36-year-old married white woman, was admitted to the Tampa Municipal Hospital on May 15, 1953, giving a history of recurring episodes of rheumatic fever since 1935. It was the opinion of the cardiologist that this patient had a severe mitral stenosis, grade IV according to the classification of Bailey, Glover and O'Neill, and that mitral commissurotomy was indicated. She had reached the point where she was unable to continue with her housework and was bedridden much of the time because of limited cardiac reserve. The prognosis without surgery was considered hopeless in view of the progressive nature of this patient's disability.

The patient was a thin white woman lying in bed with the head elevated on three pillows. She appeared to be somewhat short of breath on the slightest exertion. No cyanosis or clubbing of the extremities was noted. Some distention of the neck veins was present. Examination of the lungs revealed congestive rales throughout the posterior lung fields. The cardiac impulse was readily visible in the sixth intercostal space at the level of the anterior axillary line. Auscultation disclosed a harsh diastolic rumbling murmur ending in a snapping second sound at the mitral area, and an accentuated pulmonic second sound. Heart rate was 68 beats per minute, and the rhythm was interpreted as a slow auricular fibrillation. The liver was found to be enlarged 8 fingerbreadths below the costal margin and extended to the left side of the abdomen as far as the midclavicular line; the spleen was palpable 2 fingerbreadths below the costal margin.

Although the patient was considered to be in mild chronic failure and therefore in the poor risk group, it was felt that surgery offered the only chance for prolongation of life in this case. The greatly enlarged left auricle, very limited cardiac reserve, enlarged liver, and history of angina, all were considered factors which increased the risk of operation.

Operation was performed on May 22, 1953, endotracheal ether-oxygen anesthesia supplemented with intravenous procaine being used. The thoracic cavity was entered through the left fourth intercostal space. The pericardium was extensively opened anterior to the phrenic nerve and was sutured to the chest wall to retract it from the operative field. A purse-string suture of No. 2 white braided silk was placed around the base of the left auricular appendage. When this had been accomplished, the Glover auricular appendage clamp was applied across the appendage distal to the suture and the appendage opened distal to the clamp preparatory to insertion of the index finger. At this point cardiac action suddenly stopped. After waiting approximately one minute, during which time no cardiac activity occurred, the operator firmly grasped the heart in his left hand and methodically compressed at a rate of 40 to 50 times per minute. It must be remembered that the auricular appendage clamp was in place during this time and could not be removed because the auricle had already been opened. This clamp was steadied by the assistant while the surgeon massaged the heart. During the subsequent 15 minutes, an occasional sporadic contraction occurred but was not maintained and each time the heart again stopped beating. Cardiac massage was required for a 24-minute period before continual spontaneous beating was resumed.

While the surgeon was performing cardiac massage, the anesthesiologist kept the lung intermittently expanded by means of positive pressure and administered 100% oxygen. At the moment of onset of cardiac arrest, intravenous procaine and blood which were running were stopped and the patient was given atropine, 1/75 grain (0.8 mg.) intravenously in an attempt to cut down cardiac irritability. During the period of arrest it was possible to feel pulsations in the temporal artery produced by the cardiac massage. The pupils became fixed but not dilated. When spontaneous rhythm had been restored to about 32 beats per minute by cardiac massage, atropine, 1/100 grain (0.6 mg.) and methamphetamine (Desoxyephedrine) hydrochloride, 10 mg., were given intravenously, with an immediate increase in rate to about 120 per minute. During the ensuing half hour in an attempt to produce cerebral dehydration following the hypoxic period of 24 minutes, 50 cc. of normal serum albumin was given intravenously.

Cardiac action was observed for approximately 15 minutes after spontaneous rhythm had been restored. In view of the fact that the auricle had already been prepared and only several minutes would be required to complete the commissurotomy, it was decided to proceed with the

operation. It was also felt that overcoming the mitral stenosis would improve the patient's chances of recovery. Accordingly, the right index finger was inserted through the left auricular appendage and the mitral valve approached. The valve was found to be extremely stenotic, having an opening the size of a match head. Small calcified vegetations were palpated along the edges of the valve leaflets. The anterolateral commissure was opened by means of finger fracture as far as possible, and the posteromedial commissure was then partially divided for a short distance. When this had been accomplished, the valve opening measured approximately 2.5 cm. It was felt that the valve would accommodate at least two fingers and possibly slightly more. In view of the patient's precarious condition, it was felt that a satisfactory dilatation had been performed by means of finger fracture and the commissurotomy knife was not used. The finger was withdrawn from the auricle and the purse-string suture was approximated by the first assistant. The distal portion of the auricular appendage was amputated and the stump oversewn with a continuous silk suture. The pericardium was closed with a series of interrupted sutures, the lung was expanded, and the chest wall was closed in the usual manner with an intercostal tube being left in place for water-seal drainage for 24 hours.

Blood pressure following surgery rapidly stabilized at 110/80 and the pulse rate varied between 100 and 120. Respirations were between 24 and 36. The thoracotomy tube was removed in 24 hours. Rectal temperature for several days following surgery ranged between 102 and 104 F., but by the fourth postoperative day it had returned to normal. The patient was discharged from the hospital on June 9, 1953, her 18th postoperative day, in fair condition.

SUMMARY

A case of cardiac arrest occurring during commissurotomy for mitral stenosis is reported. The action of the heart stopped just prior to entering the auricle with the index finger. During the subsequent 24 minutes, adequate circulation was maintained by means of manual cardiac massage and oxygenation was carried out by administering 100 per cent oxygen under positive pressure. Following restoration of spontaneous cardiac action the surgical procedure was completed and the patient was returned to her room in a satisfactory condition. Reaction from anesthesia was prompt and complete and no evidence of cerebral damage was noted then or subsequently. This case is reported because of the rather unusual length of time required for the heart to resume spontaneous action and the absence of any evidence of cerebral damage, perhaps because of the immediate institution of effective massage, as shown by palpable pulsations in the temporal artery. This should encourage others in meeting a similar situation to continue their efforts for a long period of time.

SURGICAL TREATMENT OF GENITAL ELEPHANTIASIS

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TWO MAJOR types of scrotal elephantiasis, arabum (tropicum) and nostros (nostra) are recognized.[1] Elephantiasis arabum develops secondary to filarial blockage of lymphatics; the nostrum type is sporadic and due to nonfilarial obstruction of lymph drainage from the inguinofemoral areas. Of the latter group, lymphopathia venereum is probably the most frequent venereal cause in this country. Granuloma inguinale, which may not actually be a true "venereal" disease,[2] is less commonly an etiological agent.[3]

Medical treatment is ineffective for long-standing elephantiasis of the genitalia from whatever cause. In both lymphopathia venereum and granuloma inguinale, the maximum value of antibiotic therapy is attained if treatment can be administered early.

There has been little published in America on the surgical treatment of scrotal elephantiasis. Hinman [3] depicted a radical surgical removal of the scrotum by Kretchmar and recommended this procedure, to be followed by plastic formation of new penile and scrotal coverings. McDonald and Huggins [4] described a Torek-like approximation of the enlarged scrotum to the thigh, thus exploiting uninvolved lymphatic channels to replace those obstructed in the scrotum. However, their technique is applicable to relatively minor enlargements of the scrotum in which mechanical hindrance from the hypertrophy itself is not disabling.

Hovenanian [5] in 1949 reported a case of large genital elephantiasis nostros in a 74-year-old man for which the etiology could not be determined. A perineal prostatectomy had been performed 12 years prior to development of the genitomegaly; epididymitis with scrotal cellulitis had been present 3 years before the tremendous scrotal hypertrophy occurred. The possibility that these events may have contributed to the eventual elephantiasis was mentioned. Surgical treatment was carried out in two stages, the first consisting of excision of the scrotum and bilateral orchiectomy. At a later operation, an edematous prepuce and edematous suprapubic tissue were removed. A good final result was achieved. In an earlier publication Muller and Jordan [6] cited three cases of scrotal elephantiasis treated by surgical removal of the lymphedematous tissue. A good discussion as to etiology of elephantiasis and a review of the literature of that period was given.

The following case is unusual because of a duplicity of etiological factors and also because squamous cell carcinoma developed at one scrotoperineal border. The surgical method employed in the correction of this massive scrotal and penile enlarge-

ment has no known precedent, simply because suitable literature was not available to us. While no claim is made for originality, any criticisms should be directed at us alone. The surgical result has so far been satisfactory.

REPORT OF CASE

W. L. M., a 41-year-old, unmarried Negro gardener was seen Oct. 15, 1952, for relief of malodorous degeneration of a portion of a hugely enlarged scrotum and penis (Fig. 1). He stated that in 1936 a reddish ulceration appeared on the penile coronal sulcus. A physician prescribed "local applications" without effect. Within two weeks, a right inguinal lymph node enlarged and soon broke down, draining purulent material. Before the first node had healed completely, a chain of left inguinal nodes became enlarged. Concurrently a fluctuant right

Fig. 1.—Anterior view of genitomegaly. Necrotic lesion at left scrotoinguinal area.

inguinal node appeared. Over a four-month period, the progression of the disease could not be altered either by stibophen (Fuadin) therapy or by many other drugs given orally and intravenously. A circumcision was performed for balanitis. Shortly thereafter, scrotal incision and drainage were necessary for urinary extravasation. Following recuperation, no further urinary obstruction supervened, despite the remarkable enlargement of the genitalia.

During the next 14 years, countless treatments were given unsuccessfully. The scrotum and penis grew steadily larger in all dimensions. On Dec. 28, 1949, the patient was studied at the Medical College of Georgia by Dr. Robert Greenblatt. At that time, the blood complement fixation test for lymphopathia venereum and the Frei intradermal test for the disease were both positive. Smears from the granulating left thigh area contained Donovan bodies; the intradermal Donovan antigen test also provided positive result. Chancroid was ruled out by negative Ducrey antigen intradermal test. In the following five months a total dose of 112.5 gm. of chlortetracycline (Aureomycin) was administered intravenously and orally. While antibiotic therapy was being received, the draining scrotal sinuses temporarily closed, but they periodically reopened and drained seropurulent material.

During the six months following completion of the chlortetracycline therapy, rapid increase of the elephantiasis took place in all dimensions. Wart-like folds formed on the tremendously enlarged scrotum, which now reached almost to the knees. The urethral meatus presented about 6 cm. above the right anterolateral aspect of the bottom of the scrotal mass. However, the patient stated that he could void without difficulty. The downward pull of the scrotal mass resulted in a distorted gait. He could identify the penis upon the dorsal aspect of the large scrotum and pointed out the distal location of the urethral meatus. Although he had had no sexual intercourse for 14 years, there were occasional erections.

Physical examination revealed a healthy-looking, light-pigmented Negro about 40 years of age, who carried his scrotum in a burlap sack with both hands; an indescribably foul odor of

Fig. 2.—Air cystogram with ureteral catheter outlining urethra.

necrotic tissue emanated from the genital area. Abdominal examination showed a V-shaped scar of the lower abdominal wall, consisting of fibrotic skin reaction, located over each superficial inguinal lymph node chain. In the right inguinal area, about 5 cm. inferior to the anterior superior iliac spine, an indurated elevation 8 cm. in length, 5 cm. in width, and 3 cm. above the skin surface was present. This was probably marked cicatrization of a lymph node (Fig. 1).

The genitalia could not be differentiated as such. The scrotal mass, from the symphysis pubis to its most dependent edge, measured 37 cm. The greatest tranverse diameter was 20 cm., and the largest anterior-posterior measurement proved to be 15.2 cm. At the left scrotoinguinal junction, a beefy-red, elevated, friable, necrotic, ulcerated, foul-smelling lesion was located, measuring 12 cm. in its anteroposterior plane, 7 cm. superoinferiorly, and 4 cm. at the anal fold, its point of greatest depth. The remainder of the scrotal skin was composed of innumerable, confluent, rugal folds, creased and elevated in warty formation. There were several isolated, discrete areas of pinkish depigmentation on the lowermost anterior surface of the scrotum. No

glans penis could be identified, but a whitish, rubbery crater encircled the urethal meatus which was located 35 cm. below the bladder neck, as determined by the length to which a 10 F. ureteral catheter could be passed before clear urine began to drip (Fig. 2).

The perineum was normal other than for posterior extension of the ulcerated left groin lesion to within 2 cm. of the left lateral anocutaneous margin. The extremities were not edematous.

Laboratory analyses were normal other than for anemia (erythrocyte count of 2,375,000). Serological tests for syphilis were negative. The Frei test was negative on two occasions. A direct smear and biopsy of the ulcerated scrotoinguinal lesion were made by Dr. Lee Howard Jr. in a search for Donovan bodies; none was found.

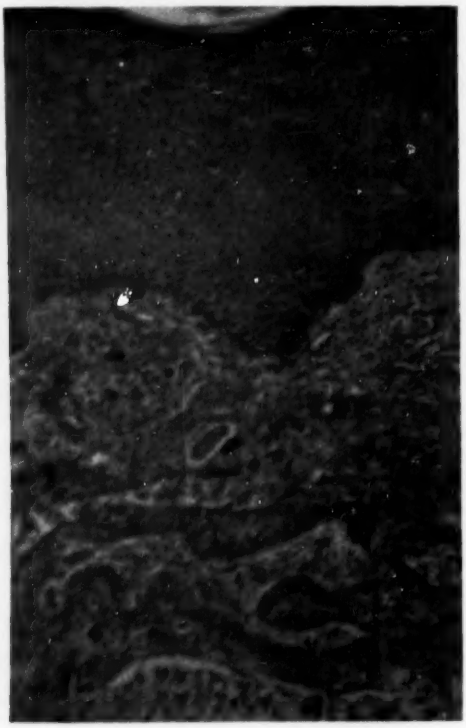

Fig. 3.—Squamous cell carcinoma in depths of scrotal skin from left inguinoperineal area; × 80.

Gauze sponges saturated with Dakin's solution were applied constantly to the ulcerated area at the left scrotoinguinal junction for nine days, resulting in a fairly clean, granulating surface. No systemic chemotherapy was given.

On Oct. 24, 1952, the first operative attack was made. Spinal tetracaine (Pontocaine) solution, supplemented by intravenous thiopental (Pentothal), was used for anesthesia. The surgical procedure consisted of amputation of the scrotum; excision of the left inguinoscrotal ulceration, and of the right inguinoabdominal cicatricial elevation; amputation of terminal 4 in. (10.16 cm.) of penis; bilateral "bottle" hydrocelectomy, and plastic closure of the skin defects of the perineum, groins, and anterior abdominal wall. Blood transfusion was given primarily to correct the existing anemia. Mechanic's waste was used liberally as the base for a pressure dressing over the entire operative site, including the subcutaneously buried penis, leaving an outlet only for an indwelling 20 F. Foley urethral catheter.

Camphorated opium tincture (4 cc., t.i.d.) was given postoperatively for five days. Chlortetracycline (250 mg.) was adminstered orally every 4 hours for the first 48 hours and then every 6 hours for eight days longer against the possibility that any residual granuloma inguinale would persist. Dressings were left intact for five days, during which time the patient remained in bed with his legs bound together by adhesive tape. Sutures were removed on the seventh postoperative day; there was incomplete coaptation of the wound at the left inguinoscrotoperineal area.

Upon examination by the pathologist, the scrotal masses weighed 26 lb. (11.8 kg.). The scrotum was covered by "a relatively flattened but intact squamous epithelium, beneath which there was an edematous, collagenous connective tissue which was moderately vascular but completely devoid of any inflammatory reaction. Sections from the margins of the ulcerated area

Fig. 4.—Final surgical result, 25 days after second operation.

showed a very thick, hyperplastic squamous epithelium with broad elongated pegs but intact basal layers. The underlying stroma was very edematous, markedly vascular, and free of inflammatory reaction. The ulcerated lesion consisted of large and small nests of squamous-type tumor cells with moderate nuclear variation and, in some areas, keratinization. Necrosis existed in the center of many of these nests. Fibrous interdigitations separated the tumor nests and contained a heavy infiltration of inflammatory cells. A large lymph node showed scarring and hyperplasia, but no tumor."

Final Pathological Diagnosis: "Massive elephantiasis of scrotum and penis with a very large squamous cell carcinoma of scrotal skin. No indication as to primary cause of elephantiasis identified now. Squamous cell carcinoma of skin probably secondary to chronic irritation (Fig. 3); all tumor appears to have been removed."

On the tenth postoperative day under intravenous pentothal sodium anesthesia, secondary closure of the wound defects was done with silver wire sutures. A penicillin-streptomycin preparation (Dicrysticin), 2 cc. twice daily, was administered intramuscularly from this time until discharge from the hospital.

Five days after the operation the urethral catheter was removed, and voiding was accomplished easily by turning the body to one side. Gradual movements of the legs were permitted after the fifth day, and on the eighth day ambulation was permitted.

The silver wire sutures were removed 10 days after secondary closure. It was seen that the wound edges had separated rather widely at the left perineal-inguinal area. It was decided to allow this region to fill in by granulation from below.

The final operation was carried out one month after the first, employing intravenous thiopental (Pentothal) sodium and inhalation cyclopropane anesthesia. The procedure entailed freeing of the penis, excision of a roughly circular area around the cutaneous base of the penis, and application of an abdominal wall skin graft of 10/1,000 in. (0.254 mm.) to the penile shaft, taken by Dr. William Lippitt by means of the Brown electrodermatome. Closure of the abdominal wall wound and that of the perineum was made with fine silver wire.

A 20 F. Foley urethral catheter was left indwelling in the urethra and the newly formed, 5-in. (12.7 cm.) long penis. The abdominal and perineal wounds were covered with plain gauze sponges held in place with a T-binder. The penis was left uncovered and was held aloft, free of contact with the dressings, by tying the distal end of the catheter across a rib of a "cradle" placed on the bed over the abdomen and legs.

After 10 days of bed rest, the urethral catheter was removed, as were the silver wire abdominal and perineal skin sutures. All areas had healed per primum. Urinary control was perfect; the stream was of good size and force. Urethral calibration with metal sounds, sizes 12 through 20 F., was easily performed twice during the following week. The patient was dismissed from the hospital two months from the time of admission.

After several weeks, he admitted to having had intercourse the very first night he left the hospital and frequently thereafter. He continued to void perfectly. The urine remained microscopically negative. Plain metal sounds were passed easily to size 22 F. Slight, superficial, exuberant granulation tissue in the left groin, noted shortly after release from the hospital, disappeared after local applications of silver nitrate within two weeks.

The final result is shown in Figure 4.

COMMENT

In essence, the plastic surgical principle of excision of lymphedematous tissue down to underlying muscles was applied here, as expounded by Blocker [7] and Farina [8] in the treatment of elephantiasis of the legs (Kondolean operation).

Split-thickness skin grafts were used to cover the surgically denuded penis in a way similar to the methods described by Ferris [9] and by Davis and Berner.[10] A high subcutaneous placement of each testicle into the anteromesial groin was performed, causing one testis to lie higher than the other for the purpose of avoiding trauma during adduction of the legs. By setting each testis as far posteriorly as its spermatic cord would allow, maximal freedom of abduction of the legs was permitted.

Although Hovenanian [5] did not state whether the penis was involved in his case of scrotal elephantiasis, he did not attempt to free the penis completely. In our relatively young man it was believed desirable to preserve the testes, in contrast to Hovenanian's castration of his patient.

In the technique of utilizing no pressure dressings against the penile skin graft, departure was made from the recommendations of most writers.[9] The process of healing could be observed by the patient and this proved psychologically helpful.[11] Furthermore, apposition of the skin graft to the phallus took place uneventfully—which speaks favorably for further trials of this "exposed wound" plan for satisfactory healing in this area.[12]

Aside from the technical difficulties that would have attended plastic formation of a scrotal sac on this markedly scarred perineum, we agreed with Davis and

Berner as to the improbability that any thermoregulatory function would be achieved by the new sac.[10] Since preservation of spermatogenesis [11] was of little concern to the present patient, the existing surgical result will not be revised.

SUMMARY

Few publications on the surgical treatment of extreme degrees of late genital elephantiasis were found. A case of huge scrotopenile elephantiasis due to granuloma inguinale and lymphopathia venereum in which squamous carcinomatous degeneration had supervened at one skin border was cited in detail. Satisfactory surgical repair was achieved. Minor technical modifications in the plastic surgical principles and in the methods of postoperative care applied in this case were described and discussed.

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CHOLEDOCHOLITHIASIS WITH CONGENITAL ABSENCE OF GALL BLADDER

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JAUNDICE due to common duct stones in association with congenital absence of the gall bladder is an extremely rare condition, since agenesis of the gall bladder itself is a rare anomaly. In 1945 Dixon and Lichtman [1] reviewed 50 cases reported previously and added 10 cases studied at the Mayo Clinic. Stones were present in 27% of the cases. In 1947 Latimer, Mendez, and Hage [2] collected 71 cases from the literature and added 3 cases of their own. In this series of 34 cases operated on, stones were found in 11. Villareal [3] in 1948 reviewed 60 cases reported since 1900, and stones were found in the common duct or hepatic duct in 18 of 37 cases. The incidence of congenital absence of the gall bladder has been reported as being approximately 0.065%, on the basis of data obtained from autopsy material and clinical reports.

Embryologically, the anlage of the biliary tract and liver arises from a ventral outgrowth of the entoderm in the region of the anterior intestinal portal. The cranial portion of this anlage gives rise to the biliary ducts, and the caudal portion gives rise to the gall bladder and cystic duct. The anlage of the hepatic diverticulum and the biliary-passage portion, or the cranial portion, remains solid until the seventh week, when a lumen develops. If the caudal outflow fails to develop, the gall bladder and cystic duct will be absent.

Approximately half of the cases are reported from surgical procedures, while the other half are autopsy findings. The average age is approximately 46 years. The frequency of this finding in clinical reports was twice as common in females as in males. Autopsy reports reveal its incidence to be approximately the same, showing that the occurrence of the anomaly has little relation to sex. However, symptom-provoking explorations of the biliary tract in cases with agenesis of the gall bladder show the same ratio as do explorations for cholelithiasis and choledocholithiasis in the presence of a gall bladder.

Stone formation within the biliary tract, in the absence of a gall bladder, was encountered at operation in a jaundiced patient, and the findings form the basis of this report.

REPORT OF A CASE

J. K., a 70-year-old white man, was admitted to the hospital on June 7, 1953, with a history of recurrence of jaundice two weeks prior to admission. With the onset of jaundice, the patient experienced severe upper abdominal pain, was nauseated, and vomited. The pain in the abdomen increased in severity, as did the jaundice. The patient noticed dark urine and light-colored stools. He had lost his appetite and approximately 8 to 10 lb. (3.6 to 4.5 kg.) within the two weeks prior to admission.

Approximately one year previously the patient experienced colicky pain in the upper abdomen with some nausea, which was relieved by glyceryl trinitrate U. S. P. (nitroglycerin) tablets. At the time, the pain was believed to be anginal in origin. In December, 1952, he had the onset of upper abdominal pain and jaundice. When the jaundice became very intense, he sought the aid of a physician and was hospitalized. Work-up revealed the cephalin flocculation to be 4 + in 48 hours, and a diagnosis of hepatitis was considered. With supportive therapy, the jaundice receded slowly, and the patient felt well. During and after this period of hospitalization, x-ray studies were performed to rule out pancreatic disease, upper gastrointestinal disease, and gall bladder disease. Three oral cholecystograms were performed, and nonvisualization of the gall bladder was reported on each examination. The jaundice cleared completely, and the patient remained well until two weeks before his present hospital admission.

On physical examination, he was thin and wiry, in good general condition, but with marked scleral icterus and a deeply jaundiced skin. Abdominal examination revealed percussion tenderness over the right costal margin. The liver was felt 2 fingerbreadths below the costal margin, and tenderness was elicited on palpation of the liver edge. There was slight right upper quadrant muscle spasticity, with some questionable rebound tenderness.

Cholangiogram obtained on 27th postoperative day. Arrows demonstrate filling of pancreatic duct and common entrance of pancreatic and common duct into ampulla of Vater.

Significant laboratory findings were as follows: Urine, bile 2 +; urobilinogen, negative; stools, clay-colored. White blood cell count 12,800. Polymorphonuclears 59, stab forms 5, lymphocytes 31, and monocytes 5. Sedimentation rate 28 mm. in one hour. Cephalin flocculation test, 1 + in 48 hours. Prothrombin time, 16 seconds (normal); alkaline phosphatase 6.8 units (normal 2 to 4 units).

Because of the nonvisualization of the gall bladder on previous oral cholecystograms and the recurrence of jaundice with abdominal pain, a diagnosis of chronic cholecystitis and cholelithiasis with choledocholithiasis was made, and laparotomy was advsed. This was carried out on June 18. At operation a markedly dilated common duct was found. There were two ductal stones present, one of which was impacted at the ampulla. There was no evidence of a gall bladder or cystic duct. The quadrate lobe of the liver was well formed, and no evidence of an intrahepatic gall bladder was found at exploration. The common duct was dissected free from the junction of the right and left hepatic ducts to the ampulla. The common duct was opened; the stones were removed, and a No. 20 F. T-tube was inserted. The patient made an uneventful postoperative recovery, and the jaundice cleared rapidly. Cholangiography performed on the ninth postoperative day revealed only a slightly dilated common duct and left biliary tree, with no roentgen evidence of obstruction or opaque or nonopaque biliary calculi. The patient was discharged from the hospital with the T-tube clamped and with no discomfort. On July 15, a repeat cholangiographic study (Figure) was performed, revealing some reduction in the size

of the common duct, again with no evidence of obstruction. On July 24, one month postoperatively, the T-tube was removed. The patient has remained symptom-free and has been followed carefully to the present date (Dec. 5, 1953).

COMMENT

The finding of stones in the biliary tract in association with congenital absence of the gall bladder is on theoretical grounds a paradox. Naunyn [4] (1892—Klinik des Cholelithiasis) postulated stone formation only in the gall bladder, inasmuch as the gall bladder mucosa is the only portion of the biliary tract which can secrete mucin, considered necessary in the formation of stones. In some postcholecystectomy patients who have had a careful search for stones and negative cholangiography at operation biliary-tract stones are found subsequently. Carter [4] has postulated that stones may form primarily in the biliary ducts, intrahepatic or extrahepatic. The precise mechanism of this stone formation is speculative. The biliary ducts may take over the function of the gall bladder and concentrate the bile, or stasis may take place when there is sphincter spasm or chronic pancreatitis with ampullary dysfunction. The finding of biliary stones when the gall bladder is congenitally absent is convincing proof that stones may be formed outside the gall bladder.

It is not possible to make the diagnosis of congenital absence of the gall bladder preoperatively. One should be aware, however, of this condition when surgery is contemplated for biliary tract disease, in cases in which extensive laboratory work reveals persistent nonvisualization of the gall bladder following oral cholecystography. Kobacker [5] reported two cases in sisters in whom exploration for upper abdominal complaints was performed because of nonvisualization of the gall bladder. Both cases were found to have congenital absence of the gall bladder, without choledocholithiasis. This finding would tend to favor the hereditary nature of this anomaly. Whenever agenesis is suspected, a careful search should always be made for an intrahepatic gall bladder.

It is interesting to consider the future course of these postoperative patients who have common duct stones removed. Since the surgical procedure merely removes the obstructing stone and the factors making for stone formation remain, it is possible that these patients may be subject to future obstructive jaundice due to new stone formation. Follow-up reports on this type of case would ascertain the frequency of recurrent choledocholithiasis.

SUMMARY

A case of obstructive jaundice due to common duct stones in a 70-year-old white man with congenital absence of the gall bladder is reported. This finding furnishes convincing proof that stones may be formed in the biliary tract outside the gall bladder.

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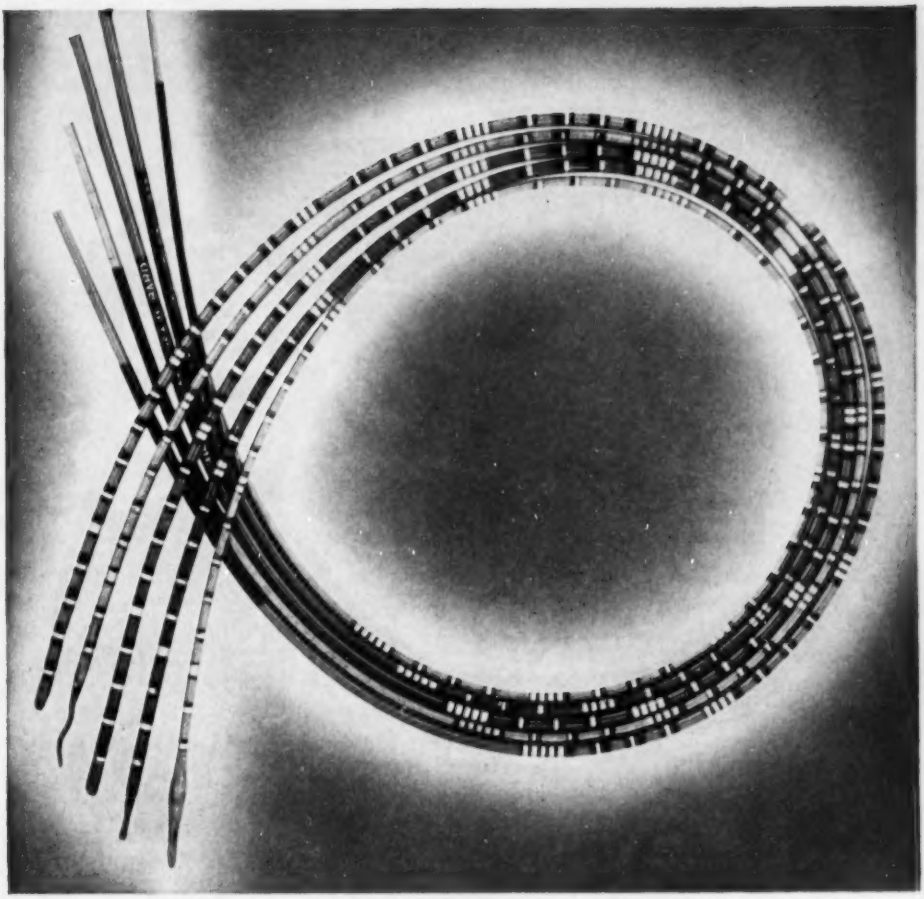

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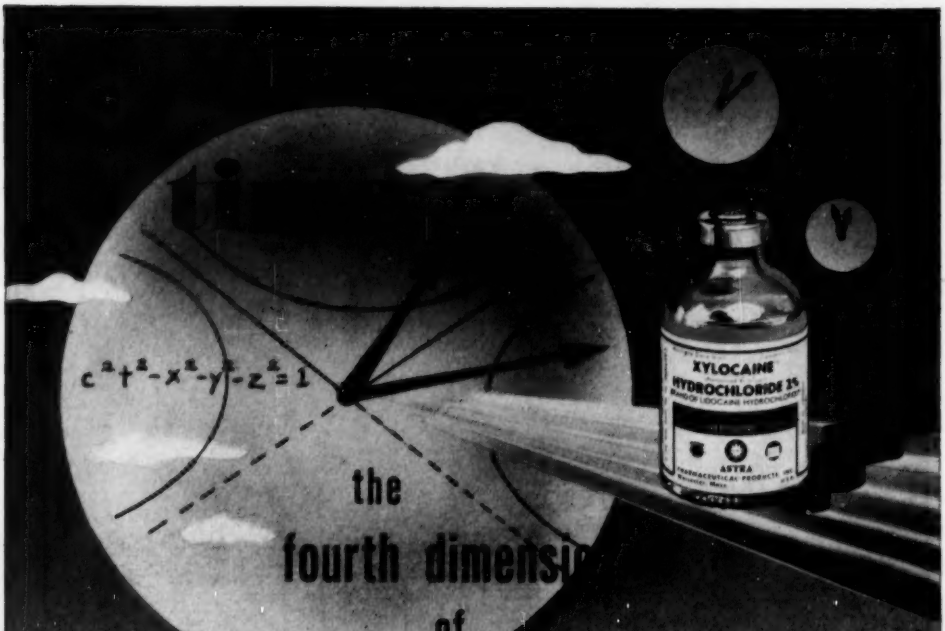

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